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SECTION A.—PHYSICS.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JULY 1916.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JULY 1916.

GENERAL PHYSICS.

744. *Artillery Chronoscope.* (Engineering, 101. p. 485, May 19, 1916.)—The ordinary stop-watch has a balance which beats fifths of seconds, and so no greater accuracy is possible than one-fifth of a second. When timing the flight of projectiles an interval of $\frac{1}{5}$ sec. may correspond to 400 ft. of range—a considerable distance. To enable a nearer approach to be made to accurate measurement, the firm of S. Smith and Sons have brought out a chronoscope beating hundredths of a second. Illustrations are given of the face and the mechanism. An interval of 3 mins. 3 secs. can be recorded. The mechanism is very similar to that of the ordinary stop-watch, but the hair-spring is much stiffer, to give the necessary short period to the balance-wheel. A. W.

745. *Graphical Method for the Solution of Algebraic Equations.* **H. G. Deming.** (Science, 43. pp. 576–580, April 21, 1916.)—Detailed description is given of a graphical method of solving equations of the type $f(u) . f(x) + f(v) . F(x) + f(y) = 0$ where $f(u)$, $f(v$, $f(x)$, and $f(y)$ are the same or different functions of the variables. The paper is illustrated by diagrams, and particular examples are solved by the method. A brief abstract cannot be given. A. W.

746. *Further Study of Floating Equilibrium.* **T. W. Richards** and **G. W. Harris.** (Am. Chem. Soc., J. 38. pp. 1000–1011, May, 1916.)—In two recent preliminary papers [see Abs. 892 (1914)] it has been shown that the exceedingly sensitive floating equilibrium of a suitably shaped float suspended in a solution of the same density may perhaps be capable of a variety of useful applications—on the one hand, to methods of chemical analysis, and on the other to the calibration of thermometers, as well as to the study of the coefficient of expansion of the float or the liquid. The present paper describes very briefly further experiments concerning: firstly, the precautions necessary for quick and accurate determination of the floating equilibrium; secondly, the thermal hysteresis of glass floats; thirdly, the effect of changing atmospheric pressure upon their behaviour; fourthly, the effect of traces of common

impurities in water; and finally, the temperatures of floating equilibria of the floats in various dilute solutions of hydrochloric acid, which afford a means of analysing the solution or of standardising approximately a given interval in a thermometer. The apparatus used receives detailed description, as also the methods employed for the preparation of materials. The results obtained are as follows:—The solubility of paraffin in water was found on examination to be very small, and in consequence, for many purposes, the use of paraffin-lined bottles as containers for standard solutions is recommended. Several newly described precautions, necessary for very exact work with floating bulbs in determining floating equilibrium, are recorded, and the effects of electrostatic charge, of varying pressure on liquid and float, and other possible causes of error, were studied in detail. The slow contraction of glass after fusion has been studied over a long range, as it is a very important possible source of error. Air dissolved in water at 20° has been shown to affect the density of water by less than 0·000 000 2. Concentration-temperature curves have been studied with several floats made of different kinds of glass in dilute solutions of hydrochloric acid. Such curves may be used for analysing such hydrochloric acid with the help of similar floats and a standard thermometer, or for subdividing intervals of an uncalibrated thermometer. Until floats of perfectly definite composition are obtained, however, results for any one float cannot safely be used with another without preliminary testing on both ends of the range employed. Because of the almost identical coefficients of expansion of very dilute solutions, the beginnings of such a curve may perhaps be used for many other solutions besides hydrochloric acid; it becomes a curve connecting approximately the density of any very dilute solution with the temperature of floating equilibrium. Thus densities can be determined thermometrically. The method will probably be more useful with such dilute solutions than with any others, but a look-out must be kept for the change in the concentration of the hydroxyl ion in extreme dilutions of an acid. H. H. Ho.

747. *Endurance of Metals under Alternating Stresses.* **B. P. Haigh.** (West of Scotland Iron and Steel Inst., J. 23. pp. 17–49; Corres., 51–56, Nov., 1915. Am. Soc. Mech. Eng., J. 38. pp. 344–346, April, 1916. Abstract. Mech. Eng. 37. pp. 315-317, April 28, 1916.)—A distinction is drawn between "proving tests" and "experimental research." Mainly on account of the time required to carry out fatigue tests they have seldom been specified as proving tests, and it appears unlikely that they will ever form part of the regular series of tests imposed by specifications. At present it is impossible to forecast the results of a fatigue test on a metal from a knowledge of its other mechanical properties; but this may be possible after the accumulation of additional data. A number of tests have shown that the modulus of elasticity of annealed iron or steel is always reduced by straining in tension, providing that the hysteresis effects are eliminated before making the second determination of the modulus. This leads to the view that the increased strength of the amorphous material is accompanied by a decrease in its modulus of elasticity. Experiments on wrought iron indicated that the max. diminution of the modulus brought about by strain is about 6·5 % of the value for annealed material. The mode of breakdown of metals under alternating stresses is discussed. It has been shown that polishing the surfaces of specimens increases the resistance to endurance bending tests. A number of fatigue tests on various metals and alloys are described, and the results indicate that the modulus of elasticity is no criterion as to the behaviour of the metal under fatigue tests.

 F. C. A. H. L.

748. *Elastic Peculiarities of Phosphor-Bronze Wires.* **L. P. Sieg** and **A. J. Oehler.** (Acad. Sci. Iowa, Proc. 22. pp. 321–326, 1915.)—Previous experiments on platinum-iridium [see Abs. 10 (1911) and 147 (1913)] suspension wires showed some complicated relations between the period of vibration and the amplitude of swing. The present paper describes the results of similar experiments on 13 phosphor-bronze drawn wires of diams. ranging from 0·100 to 0·508 mm. It was found that, as before, a larger amplitude gives a greater period of swing, though to a less extent than is the case with Pt-Ir. The actual results are exhibited graphically in the paper, and it is seen that the effect of drawing the wires is to make the departure from the ideal elastic solid increase steadily with the increased fineness of the drawn wire. A new effect, which might be classed as a second order of effect, superimposed on the one noted above, has been discovered. This effect is the increase in period with decreasing amplitude after a certain limiting amplitude has been reached. J. W. T. W.

749. *Aerial Trajectories of Projectiles.* **E. Esclangon.** (Comptes Rendus, 162. pp. 160–163, Jan. 24, 1916.)—The paper is a critical examination of the equation $d(v\cos\tau)/d\tau = cvF(v)/g$, where v is the velocity of the projectile at an angle τ, while $cF(v)$ represents the resistance of the air. A certain number of geometrical properties have been deduced from the assumption that c is constant, but this is only a first approximation and quite insufficient for the requirements of modern ballistics. A second approximation may be obtained by making c depend on the variation of air density (variable with altitude according to an exponential law), but neglecting variations of gravity, and the geometrical properties are then found to be considerably modified. The author proceeds to study this aspect of the trajectory problem, and, for the purpose, classifies trajectories into two categories, viz. those for which the speed possesses a minimum other than zero, *i.e.* following a maximum, and those for which there is no minimum speed, *i.e.* the latter decreasing continuously. Inflectional trajectories are found to exist as a necessary consequence, and constitute a family dependent on a single parameter.

Other interesting results are given. H. H. Ho.

750. *Influence of Atmospheric Conditions on the Trajectories of Long-range Projectiles.* **de Sparre.** (Comptes Rendus, 162. pp. 496–498, April 3, 1916.)—This paper is a revision of a previous communication [Abs. 510 (1916)], in which for the purpose of calculating the trajectory of the German gun 381, the value 0·865 was taken for the ballistic index. The author now believes a lower value should be taken, and has recalculated his results with an index 0·75 ; which gives a max. range in good agreement with the 38 km. claimed. For the German gun of 406·4 mm. the max. range should be about 40 km. The author now studies the influence of pressure and temperature on the range and develops formulæ for the ballistic index under such variations. He finds, for example, that a temperature increase of 13 deg. C., and a pressure diminution of 10 mm., would produce a range increase of 1792 m. for the gun 381, thereby demonstrating the appreciable influence of atmospheric conditions upon long-range projectiles. H. H. Ho.

751. *Hydraulic Flow Reviewed.* **A. A. Barnes.** (Engineer, 121. pp. 402–403, May 12, 1916.)—The theory of the flow of water through pipes, channels, and orifices accords very poorly with practice, and if the quantity of water which will flow through a given pipe in a given time has to be predicted the

velocity must first be calculated. For this purpose one of several formulæ must be chosen, and the result depends entirely on the selection made. The author here attempts to clear up the tangle in a book reviewed in the *Engineer* of the above date. The basis of his argument is that previous investigators have been seriously hampered by their inflexible adherence to the assumption that the index of m and i is 0·5 in the general formula $V = K\sqrt{mi}$, where m is the hydraulic mean depth of the pipe and i is its gradient. The author maintains that if the correct indices are chosen for each particular class of pipe or channel, one value of K can be found which is correct and invariable for all values of m and i in that class. He starts with the formula in the form $V = Km^{\alpha}i^{\beta}$ and by applying a species of logarithmic plotting to the results of all available experiments, proceeds to the determination of the three quantities κ, α, β. It is shown that all three constants can be determined for any given type of pipe or channel if three accurate observations are to hand. Some 16 classes of pipes, troughs, channels, conduits, water-courses, etc., are covered. The author next applies his method to the flow of water through triangular notches, weirs, and circular orifices with the same marked success.

H. H. Ho.

752. *On Five-fold Variety in the Physical Universe.* **J. Ishiwara.** (Tôhoku Univ. Sci. Reports, 5. No. 1, pp. 1–32, 1916.)—In a recent paper [see Abs. 1437 (1914)] Nordström has described the remarkable discovery that the electromagnetic field and the gravitational field together are characterised by a 10-component vector in a five-fold variety of space, time, and a fifth variable ω. The latter variable plays a special rôle, in that the component of the universal potential and of the field vector give along this variable the corresponding quantities in the gravitational field. The equations developed in this way give results possessing important physical significance if the differentials of similar quantities with respect to "ω" are equated to zero. It follows that no physical change of state takes place in this direction. In view of the novel character of the variable ω, Nordström has discovered certain new relationships which are of profound significance, and lead to a five-dimensional nature being ascribed to the physical universe, this being an extension of Minkowski's fundamental idea. In the present paper the author systematically studies Nordström's equations and then develops some new relationships. Use is made of a five-dimensional vector analysis. Section I. of the paper contains a general discussion of multi-dimensional analysis; II. deals with the universal physical field of force; III. gives a physical interpretation to the developed equations. Only one physical postulate is made, namely, that at every point of space there is a direction "ω," along which the universal potential remains always constant. The four-dimensional space perpendicular to this direction is termed Minkowski's universe, and the principle of relativity gives the equivalence of its four axes. IV. deals with the equation of motion, and V. with the principle of work. The absolute value of the fifth velocity is a purely imaginary quantity whose physical modulus plays the part of the velocity of light propagation and also of gravitational potential. The ratio of the Minkowski time element to that of the extended system is constant for any finite material structure element, and depends in general on the mass and charge. The field equation, the equation of motion, and also the principle of work have an invariant expression in the five-dimensional universe. For deriving the complete equation of motion from the principle of work it is essential that reference be made only to such an electron which is of spherical shape when at rest, which possesses

a uniform superficial distribution of charge and mass, and in which the internal and external forces are in equilibrium. This restriction to the spherical form and the superficial distribution of the field source has not been necessary so far in the four-dimensional treatment of problems in the Minkowski universe, and these conditions are introduced to admit of simplified treatment. The five-dimensional equation of motion should be connected with the scalar principle of work, as an important consequence of the present theory. H. H. Ho.

753. *Statistical Mechanics.* **C. V. L. Charlier.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 10. 29. pp. 1–18, 1915.)—This is the first of a proposed series of notes in which the established theorems in the kinetic theory of gases will be employed for the investigation of stellar motions subject to Newtonian gravitation.

To pass, in the kinetic theory, from the velocities before, to the velocities after a collision, three parameters, corresponding to the relative co-ordinates, before the passage, determine the final velocities when the relative velocities after collision are known, in addition to the absolute initial velocities. And these parameters are reducible to two by the principle of conservation of energy when, as in statistical mechanics, only the velocities at infinite distance are considered. Two such parameters, found of value in the kinetic theory, although not fulfilling all the probability conditions, are derived from the facts that the relative orbit of any pair of stars lies in a plane and is symmetrical about the line of perihelion. The method indicated is applied to the derivation of numerical values for star densities and probabilities of stellar collisions. G. W. DE T.

754. *Hydrogen-molecule of Bohr and Debye.* **[Miss] H. J. van Leeuwen.** (K. Akad. Amsterdam, Proc. 18. 7. pp. 1071–1083, 1916.)—A mathematical discussion. [See Abs. No. 811 (1914).] E. H. B.

755. *The Distribution of Cyclonic Precipitation in Japan.* **T. Terada.** (Coll. Sci. Tōkyō, J. 37. Art. 4. pp. 1–32, Jan. 27, 1916.)—Various workers have investigated the distribution of rainfall in the different sectors of a cyclone for different localities, and a brief summary of the conclusions reached is here given. For the present investigation the author made use of records from 1905 to 1915 inclusive and confined his attention to those depressions which were well defined and free from secondaries. The pressure maps for 6 a.m., 2 p.m., and 10 p.m. were used and the whole district divided up into $2\frac{1}{2}°$ "squares." The centre of each depression was allocated for each map to one of these squares and a record made of all stations where rain was falling at the time. A network of 80 stations was used for the purpose. By taking means for each position of the centre the appropriate "probability" of rain for each station with this location of the centre is found. Thus if for a given position rain fell at a certain station 5 times out of 10 cases the "expectation" of rain is expressed in percentage as 50. This expectation of rain in each district for the different positions of the centre is set out in a table. The results are further shown diagrammatically in each of two ways: (1) by curves of equal expectation corresponding with each given position of the centre, and (2) by curves showing the locus of the position of the centre bringing equal expectation for each district. The chief results reached have already been summarised in another paper [see Abs. 530 (1916)].

The paper concludes with a theoretical consideration of the subject. In this the rainfall in the different regions of a depression is worked out on the assumption that the incurvature of the air-paths is everywhere the same. In the first place the amount of rain produced by the rising air at different distances from the centre is calculated, assuming the air to be saturated at the surface. Secondly, consideration is given to the effect of differences of temperature in different parts of the depression, and to that of the vertical motion brought about by differences in the coefficient of friction between the air and the earth, as for example, when air passes from a sea surface to a land area. J. S. Di.

756. *Strength of the Earth's Crust.* **H. Jeffreys.** (Observatory, No. 499 pp. 165–168, April, 1916.)—The note briefly reviews a series of articles published by J. Barrell, in the *Journal of Geology*, vol. 22 (1914); 23 (1915), dealing with the questions of how isostatic adjustment is produced, and the meaning of the deviations from complete compensation that are observed. C. P. B.

757. *Temperature and Radiation of the Sun.* **F. Biscoe.** (Warsaw Univ. News, 1915. [In Russian.] Astrophys. J. 43. pp. 197–216, April, 1916. Extract.)—The purpose of the first section of the paper is to determine the temperature of the sun from the intensity of radiation for individual wave-lengths in its spectrum, using the observations from the Smithsonian Institution at Washington made with the spectro-bolometer. The deduced absolute temperature of the solar surface is found to be on the average $7300° \pm 100°$ C. Other observations made by the author with the aid of colour-filters in conjunction with the Ångström compensation pyrheliometer, are also examined for variations of solar radiation over small intervals of time. C. P. B.

758. *Terrestrial Influence on Frequency and Latitude of Sun-spots.* **H. Arctowski.** (Comptes Rendus, 162. pp. 593–595, April 17, 1916.)—Examination is made of the spot numbers given by Wolfer, and the spot areas given in the Greenwich catalogues, for evidence of terrestrial influence on sun-spot phenomena. The results appear to indicate an annual variation of mean latitude of about 4°. C. P. B.

759. *Variation of Mean Heliographic Latitude of Sun-spots.* **H. Arctowski.** (Comptes Rendus, 162. pp. 501–504, April 3, 1916.)—It is sought to distinguish in the solar phenomena between those affecting terrestrial magnetism and atmospheric electricity, with a cycle of about 11 years, and others of shorter period affecting terrestrial temperature, storms, and other meteorological phenomena. The Greenwich sun-spot measures are discussed in relation to the variations of latitude during the period 1874–1913, a table being given showing the mean latitudes of selected rotations during certain epochs of solar activity. C. P. B.

760. *Nature of Coronium Atom.* **J. W. Nicholson.** (Roy. Astron. Soc., M.N. 76. pp. 415–418, March, 1916.)—It has already been pointed out in the electronic theory of series spectra that certain lines in the spectrum of the solar corona showed constant differences between their cube roots. At the last solar eclipse of Aug. 21, 1914, Deslandres and Carrasco found a

new line in the red, at λ6374·5, and it is interesting to find that this line also fits in exactly with the cube-root relation. [See Abs. 286 (1915).] Two other lines, λ4566·0 and λ3642·5, are then shown to be included in a related series, and an analysis is given showing that coronium is probably due to the simple-ring system with nucleus 7*e* and 8 electrons forming altogether a single negative charge. C. P. B.

761. *Objective Changes on Surface of Mars.* **E. M. Antoniadi.** (Roy. Astron. Soc., M.N. 76. pp. 413–414, March, 1916.)—Observers have from early days suspected the reality of changes in the markings of the surface of Mars, usually ascribed to the presence of clouds. The author considers he has been able to confirm this at Meudon, and mentions that the atmospheric veils which so frequently deformed the dark areas showed all tints from brilliant white to deep orange. Apart from this, however, from a study of all available drawings of the planet published since the beginning of the eighteenth century, he finds evidence of changes which may be secular, recurrent, or seasonal in character. Examples of these three types are given concerning the Hydaspes, Nepenthes-Thoth, and Syrtis Major. C. P. B.

762. *Observations of Jupiter.* **F. Sargent.** (Roy. Astron. Soc., M.N. 76. pp. 411–413, March, 1916.)—During the opposition of 1915, Jupiter was observed at Bristol on 90 nights. A list of rotation periods is given as reduced from 480 transits of various prominent features. On the N. edge of the N. equatorial belt 23 spots were seen of sufficient permanence to give rotation periods. The revival of activity of the S. edge of the N. equatorial belt, which began towards the end of 1912 appears to have almost spent itself. In the S. equatorial belt light spots appeared in longitude 135° about the middle of October. The Red Spot was not a prominent feature, but was frequently seen situated towards the following end of the hollow. Observations are detailed of the S. Tropical Disturbance, the S. Temperate Belt, and the Red Spot Hollow. C. P. B.

763. *Albedo of the Planets and their Satellites.* **H. N. Russell.** (Astrophys. J. 43. pp. 173–196, April 1916.)—The various values available are discussed in detail and a table is given showing for the planets and satellites (1) stellar magnitude at mean opposition; (2) equivalent magnitude at full phase and unit distance from earth and sun; (3) assumed mean semi-diameter at unit distance; (4) a factor p defined as the ratio of the actual brightness of the planet at the full phase to that of a self-luminous body of the same size and position, which radiates as much light from each unit of its surface as the planet receives from the sun under normal illumination; (5) a quantity q, depending on the laws of diffuse reflection; (6) the determined albedo; the colour-index; (8) the photographic albedo. C. P. B.

764. *Distances of the Heavenly Bodies.* **W. S. Eichelberger.** (Science, 43. pp. 475–483, April 7, 1916. Paper read before the Phil. Soc. of Washington, March 4, 1916.)—A survey is given of the gradual progress made in the investigation of stellar parallax since the earliest days of astronomical precision, when Eudoxus of Cnidus about 370 B.C. supposed that the sun was only about nine times greater than that of the moon. At present it is considered that the accepted distance, 92,900,000 miles, is correct to within 30,000 miles. Gradually the problem was extended to obtain the distances of the stars, which are, however, so distant that instruments of the highest

power are necessary to furnish any reliable results. Whereas in 1838 the parallaxes of only 3 stars were known with any approach to accuracy, in 1916 we have good values for about 300, the work being greatly facilitated by the employment of photographic registration. C. P. B.

765. *Spectrum of γ Argûs.* **W. M. Worssell.** (Roy. Astron. Soc., M.N. 76. pp. 418–421, March, 1916.)—As a gift from the late J. Franklin-Adams a prismatic camera has recently been installed at the Union Observatory, Johannesburg, comprising a Cooke triplet objective of 6 in. aperture and 108 in. focal length, and a prism with refracting angle of about 16°. Special attention has been given to stellar spectra in the green, yellow, and red regions, photographed on panchromatic plates. In the spectrum of γ Argûs many of the bright lines are conspicuously reversed, and for these the measured wave-lengths are more accurate than in the case of many of the fainter broad lines. A table is given of the lines measured on plates taken in April 1915. These plates show a greater number of bands than were recorded by Campbell, but the brighter are identical in both records, and there is no reason to think the spectrum has changed during the 21 years separating the two observations. C. P. B.

766. *Distribution of Stars in Space.* **R. J. Pocock.** (Roy. Astron. Soc., M.N. 76. pp. 421–428, March, 1916.)—An investigation has been made of the proper motions of over 400 stars, some of them faint, and comparisons made between the observed distribution and that deduced from theory, the agreement being good ; but the observed number of very large proper motions seems to be consistently less than the theoretical number. C. P. B.

767. *Changes in Spectrum Period and Light-curve of RR Lyræ.* **H. Shapley.** (Mt. Wilson Solar Observatory, Contrib. No. 112. Astrophys. J. 43. pp. 217–233, April, 1916.)—This star (7.0 mag.) is the brightest of the cluster type of Cepheid variables. Details of the peculiarities of the light variation are discussed in connection with the changes in the recorded spectrum. From the results given by 9 observers over about 15 years it is shown that the mean period is affected by a slow variation which may complete its cycle in 16·5 years. Diagrams are given to show that the maxima of the light-curve are not constant in form, and that variations exist in the times of rise to maximum. C. P. B.

768. *Periods of Eclipsing Variables.* **S. D. Wicksell.** (Astrophys. J. 43. pp. 245–247, April, 1916.)—Referring to a paper by Shapley [Abs. 1006 (1915)], in which a catalogue of eclipsing binary stars is used to investigate whether the two types of periods suspected in spectroscopic binaries are to be detected, it is pointed out that the eclipsing binaries would not be expected to give much evidence of this grouping. Attention is drawn to the tendency of eclipsing variables to show two groups according to density. C. P. B.

769. *Calculation of Co-ordinates of Photographic Catalogue Stars.* **B. Baillaud** and **Pourteau.** (Comptes Rendus, 162. pp. 533–536, April 10, 1916.)—Details are given of the reduction formulæ employed at Paris for the calculation of right ascensions and declinations of stars from measures on the plates for the photographic catalogue. C. P. B.

LIGHT.

770. *Vacuum-spectrograph for High-frequency Spectra Investigations. Application to the Study of the Rare Earths.* **M. Siegbahn** and **E. Friman.** (Phys. Zeits. 17. pp. 176–178, May 1, 1916.)—An interesting description is given of a "self-contained" instrument which is readily adapted to the study of X-ray spectra. The slit, revolving crystal table, and photographic plate are suitably mounted in a highly evacuated chamber, a neat arrangement for revolving the crystal at the required rate being devised. The reproduction of the spectrum of aldebaranium (Ad) obtained with this instrument shows a number of extremely sharp and well-defined lines. The following table gives the result of a series of wave-length measurements for the rare earths :—

Atomic Number.	Element.	$\lambda \times 10^8$ cm. α_1.	α_2.	$\sqrt{(1/\lambda)} \times 10^{-4}$ α_1.	Diff.
73	Ta	1·518	1·528	0·812	—
72	Tu II	—	—	—	13
71	Cp	1·619	1·629	0·786	13
70	Ad	1·670	1·681	0·774	12
69	Tu I	—	—	—	13
68	Er	1·783	1·794	0·749	12
67	Ho	1·843	1·854	0·737	12
66	Dy	1·907	1·916	0·724	13
65	Tb	1·973	1·983	0·712	12
64	Gd	2·043	2·054	0·700	12
63	Eu	2·121	2·131	0·687	13
62	Sa	2·200	2·210	0·674	13
61	—	—	—	—	12
60	Nd	2·369	2·379	0·650	12
59	Pr	2·462	2·472	0·637	13

A. B. W.

771. *Light Transmission through Telescopes.* **F. Kollmorgen.** (Am. Illum. Eng. Soc., Trans. 11. pp. 220–228; Disc., 228–234, March 20, 1916.)—Attention is drawn to the importance of the amount of light lost in telescopic apparatus by reflection and absorption, and of the possibility of much of the reflection loss being obviated by the glasses being subjected to certain chemical treatment (details of which are withheld). The process is stated to be an extension of that put forward by Taylor in 1904, in which the lenses, immediately after polishing, were immersed in an aqueous solution of ammonia and sulphuretted hydrogen. Flint glasses seem to be most affected by the process, while crown glasses are almost unaffected. The results are attributed to the formation of a vitreous surface layer of low index of refraction. C. P. B.

772. *Loschmidt Number.* **H. Dember.** (Ann. d. Physik, 49. 5. pp. 599–610, April 11, 1916. Reprint from the Math. Phys. Klasse d. K. Sächs.

Gesell., Leipzig.)—Describes the determination of the Loschmidt number from measurements of the extinction-coefficient of sunlight of short wave-length, a spectrophotometer being employed. The spectrophotometer was of special type in which a photoelectric cell was used. The sensitive substance in this cell was potassium, contained in a chamber filled with argon at a pressure of 0·2 mm., and the cell was used with a Wulf electrometer. The work was carried out on the peak of Teneriffe, and the mean value deduced from the observations there was found to be $2 \cdot 89 \times 10^{19}$ molecules per $cm.^3$, which is in agreement with the values found by other methods.
A. W.

773. *Photometry of West Indian Firefly.* **W. H. Pickering.** (Nature, 97. p. 180, April 27, 1916.)—Some interesting particulars are furnished by the author from his study of the firefly in Jamaica. The insect is brighter than those found in the United States and England, and first appears in Jamaica about the middle of February, becoming very numerous by June, and being specially noticeable on damp or foggy evenings when there is no moon. The light is continuously fluctuating, but may readily be seen at a distance of a quarter of a mile. The grown insect measures about 30 mm. (1·2 in.) in length, by 9 mm. (0·36 in.) in breadth. The system of lights is quite unlike that of the northern specimen, and consists of a green light on either shoulder, with a brighter orange under the abdomen, the latter only being visible when the insect is in flight. When enclosed under glass a distinct rise of temperature could be observed. An attempt was made to determine the brightness of the fly as seen against a wall 53 m. (175 ft.) distant, with known stars in the field of vision. Comparisons were thus made with Canopus (at a low altitude), and α Orionis at about 40° altitude, the firefly light being about equal to these, *i.e.* about 1 stellar mag. As a zero mag. star is about equal to 1 candle at 526 metres, the light of the firefly would be about 0·004 c.p. C. P. B.

774. *Ultra-violet Dispersion of Salts in Water.* **A. Heydweiller** and **O. Grube.** (Ann. d. Physik, 49. 6. pp. 653–670, May 5, 1916.)—The author has measured the ultra-violet dispersion of seven salts at different concentrations in aqueous solution and derived therefrom by extrapolation the dispersion of the ion solutions. It is shown that the results for the visible and ultra-violet regions agree well with the dispersion equation of Drude's theory. With two exceptions all exhibit normal values for e/m.

The specific oscillation has been estimated for the valency electrons of the SO_4, ClO_3, Cl, $C_2H_3O_2$, and CNS anions, and the frequency decreases through the series. The frequency is practically independent of the nature of the kathion. Only in the case of a very heavy kathion is there much influence, which probably is to be attributed to the formation of complex ions.

The violet absorption of weak solutions of nickel chloride arises from the formation of loosely bound complex ions. The author has estimated the concentration and electronic oscillation of this complex ion. C. S. G.

775. *Ultra-violet Metallic Spectra.* **F. A. Saunders.** (Astrophys. J. 43. pp. 234–242, April, 1916.)—Tables are given showing the wave-lengths and relative intensities of lines found in the vacuum arc spectra of Mg, Ca, Zn, Cd, Al, In, Tl, Pb, and Sn in the ultra-violet region λ2300–λ1670, and in the spark spectra of Mg, Ca, Zn, Cd, Al, In, and Tl. The results are of interest in connection with series relationships among the lines. C. P. B.

776. *Interference of Reversed Spectra.* **C. Barus.** (Am. J. Sci. 41. pp. 414–434, May, 1916.)—Gives a detailed description of further work on reversed spectra [Abs. 71 (1916)]. It now appears that beating wave-trains have not been observed, but that the striking scintillations are due to an exceptional susceptibility of the apparatus to laboratory tremors when exhibiting the phenomenon in question. What has certainly been observed is the interference of a D_1 or D_2 line with a reversed D_1' or D_2' line, both having the same source and the same longitudinal axis. It can be stated, therefore, that light of the wave-length interval of the breadth of these lines is capable of interference when the line is reversed. Some of the results here given have already been dealt with [Abs. 554 and 668 (1916)]. A. W.

777. *Pole-effect in Calcium Arc.* **H. G. Gale** and **W. T. Whitney.** (Astrophys. J. 43. pp. 161–166, March, 1916.)—In the course of work on the pressure-shift of the lines in the arc spectrum of calcium observations were made of the pole-effect of the triplets of the first and second subordinate series. It is shown that the pole-effect for these subordinate series lines depends upon the intensity gradient from pole to pole across the arc. The fact that the same wave-length was obtained with either a small or large amount of calcium present indicates that mere density of the radiating ions is probably not the underlying cause of the pole-effect, and it is suggested that possibly the amplitude of vibration of the electrons is the predominant factor. C. P. B.

778. *Extension of Spectrum beyond the Schumann Region.* **T. Lyman.** (Astrophys. J. 43. pp. 89–102, March, 1916.)—The author has recently published a brief statement of the result of his investigations on the extension of the spectrum [Abs. 846 (1915)]. The present paper contains a fuller account of the work, and includes a detailed description of the experimental procedure. Some experiments were made with an electrodeless discharge, but no radiation on the more refrangible side of $\lambda 800$ has been obtained with it. The arc discharge in quartz, both when Ca and Mg electrodes were used, showed no lines beyond $\lambda 1000$ which could with certainty be attributed to these metals. The spectra in both cases consisted mainly of secondary hydrogen lines; the primary lines at $\lambda 1216$ and $\lambda 1026$ were, however, quite strong. The spectrum, which is intense, terminates near $\lambda 905$. The absence of metallic lines in this region is also confirmed by experiments with the spark discharge at reduced pressures. Both Al and Fe terminals were used, but no lines were found beyond $\lambda 1030$. The results for helium and hydrogen are discussed at some length. The line at $\lambda 1176$ is perhaps the strongest in the whole hydrogen spectrum; it is equally strong in helium, and is very strong in nitrogen; of its origin nothing positive can be said. All the remaining lines to $\lambda 977$ are stronger in nitrogen than in either helium or nitrogen; all occur in argon. From $\lambda 997$ to $\lambda 904$ all the lines, with one exception, occur in hydrogen, helium, and argon, but with relative intensities depending on the gas in which they are produced. All the lines on the more refrangible side of $\lambda 900$ are obtained only when helium is employed, with the exception of $\lambda 833$ which occurs in argon. The strength of the pair near $\lambda 835$ is striking. Argon gives a spectrum containing many lines terminating only near $\lambda 800$, and a careful study of this spectrum will probably yield some interesting results. The paper contains a table of the wave-lengths of 27 lines between $\lambda 599$ and $\lambda 1247{\cdot}9$, and also gives photographs of four spectra. A. W.

779. *Lithium Spectrum in an Electric Field.* **H. Lüssem.** (Ann. d. Physik, 49. 7. pp. 865–880, May 11, 1916.)—Previous work on the effect of electric fields on the lines of lithium, hydrogen, and helium [Abs. 1071 (1914) and 1667 (1915)] tended to show that further investigation of the Li lines in strong fields was desirable, and hence the research here described was undertaken. The discharge tube was of the usual Stark type, and both a prism and a plane-grating spectrograph were employed. Lines from the principal and the first and second subordinate series were compared, as regards intensity, for fields up to 80,000 volts/cm. The results obtained with the lines λ6708, λ6104, and λ4972, belonging respectively to the three above series, show that the intensity ratio for the perpendicular and parallel components is practically independent of the field strength. Polarisation effects are next dealt with, and then results are given for the variation with field strength of the distance between the various components of the lines λ4603 and λ4133. It appears that the separation of the outer *p*-components for the one line bears a constant ratio to that for the other line. At first the separation increases almost in direct proportion to the field strength, but afterwards increases somewhat more slowly. Stark and Kirschbaum have observed a similar effect with the He-line λ4472, which corresponds with the Li-line λ4603. The latter part of the paper deals with the effect of the field strength on the intensity ratio of the components of the first subordinate series lines, and the displacement of the lines of the second subordinate series. The displacement towards the red of the lines of the latter series follows the general series law : it increases as the line number increases. For the line λ4273, the second member, the displacement is 1·2 Å. units, while for λ3985, the third member, it is 3·3 Å. units for a field strength of 80,000 volts/cm.

A. W.

780. *Light Emission in Spectrum Series Lines.* **J. Stark.** (Ann. d. Physik, 49. 6. pp. 731–768, May 5, 1916.)—Describes research on the duration of the light emission of series lines in canal-ray spectra. A full description is given of the experimental methods adopted, and the phenomena of the light emission behind the kathode are discussed at some length. The results of the research show that for the series lines of hydrogen, helium, and also lithium, the duration of the light emission increases as the series number increases. A calculation is made of the upper limit of the duration of the emission for the H- and He-series lines. For H_α and H_β the duration of emission (T) is shown to be less than 4×10^{-7} sec. ; for H_γ T is less than 2×10^{-7} sec. For H_δ the duration is apparently longer, about 4×10^{-7} sec. For the intense H-band lines in the blue and violet T is $< 4 \times 10^{-7}$ sec. For the He-lines λ5876 and λ4472 T is $< 6 \times 10^{-7}$ sec., and for the next member of the series T is of the order of 3×10^{-7} sec. Theoretical considerations based on some of Fabry and Buisson's results lead to the conclusion that for the He line λ5876, T is $> 7 \times 10^{-10}$ sec. and probably has a value of about 1×10^{-8} sec. The latter part of the paper deals with the connection between the duration of emission and the ratio of intensities of the displaced and stationary lines in canal rays. Further deductions from the results will be given in a subsequent paper. A. W.

781. *Theory of Stark-effect.* **P. S. Epstein.** (Phys. Zeits. 17. pp. 148–150, April 15, 1916.)—A paper dealing with the Stark-effect for the Balmer series of hydrogen. The details of the theory will be given in a subsequent paper ; the theory is based on Sommerfeld's work, and leads to the following

simple formula for the displacement of the components from the equilibrium position :—

$$\Delta\nu = (3h/8\pi^2 e\mu c)\mathrm{EZ},$$

where—

$$Z = (m_1 + m_2 + m_3)(m_1 - m_2) - (n_1 + n_2 + n_3)(n_1 - n_2).$$

h is Planck's constant, e the elementary charge, μ the mass of an electron, c the velocity of light. m and n are positive whole numbers, and the sums $(m_1 + m_2 + m_3)$ and $(n_1 + n_2 + n_3)$ correspond to the order numbers of the Balmer series, so that $n_1 + n_2 + n_3 = 2$ while $m_1 + m_2 + m_3$ for each line of the series is constant, but for the different lines H_α, H_β, H_γ... has the values 3, 4, 5.... Tables are given of the values calculated by means of the above formula for $\Delta\lambda$ for the lines H_α, H_β, H_δ, and the calculated values are seen to be in remarkably good agreement with the observations of Stark for these four lines. [See Abs. 460 (1914), 1437 (1915).] A. W.

782. *Light Absorption and Fluorescence.* IV. *Concentration and Absorption.* **E. C. C. Baly** and **F. G. Tryhorn.** (Phil. Mag. 31. pp. 417–430, May, 1916.)—A continuation of previous work [see Abs. 560, 1405 (1915)] on the relation between absorption in the ultra-violet and infra-red regions. The position of the absorption band and the variation of the absorptive power with the concentration of the absorbing substance in solution are dealt with here. In the two cases examined, pyridine and salicylaldehyde, the ultra-violet band shifts towards the red on the addition of a small quantity of solvent and then back to the ultra-violet as the concentration of the solvent decreases. With increasing dilution the centre of the absorption band approaches the true value for the vapour. The shifting of the bands in solution is due to a combination or tendency to a combination of the substance with the solvent, and of necessity the fundamental infra-red band must also shift with dilution. Inversely, the solution acts as a single entity with its own fundamental frequency of vibration in the infra-red. A new entity is formed when the concentration is altered. Consequently the derived ultra-violet frequencies must change, and change relatively more than do the infra-red frequencies, as the concentration is altered.

The variation of absorptive power with concentration has been worked out in the case of pyridine through an exhaustive range of dilutions and in various solvents. The absorptive power (k) does not follow Beer's law, and a new formula is deduced which fits the experimental values. This formula is $k/\mathrm{K} = 1 - e^{-\alpha \mathrm{V}}$, where K is the max. value of k in the given solvent, α a constant characteristic of the substance and solvent used, and V the dilution.

It is pointed out also that this formula with suitable modifications is applicable to solution phenomena in general when the mass-action law does not hold. Thus, the modification $\lambda/\lambda^\circ = 1 - e^{-\alpha\sqrt{\mathrm{V}}}$, where λ and λ° are the molecular conductivities of a solution at concentration V and at infinite dilution respectively, holds for weak electrolytes at concentrations smaller than $\mathrm{V} = 4$ and for a fair range of concentrations of strong electrolytes. C. S. G.

783. *High-frequency Spectra of the Elements from As to Rh.* **M. Siegbahn** and **E. Friman.** (Ann. d. Physik, 49. 5. pp. 611–615, April 11, 1916.)—The principal lines of the K-series, of the elements As, Se, Br, Rb, Sr, Nb, Rh, have been determined by the rotating-crystal-photographic method and the results shown to be in excellent agreement with Moseley's relation connecting wave-lengths and atomic numbers, viz. $\sqrt{(1/\lambda)} = a(\mathrm{N} - \mathrm{N}_0)$. [See Abs. 681 (1916).] A. B. W.

784. *High-frequency Spectra (L-series) of the Elements from Ta to Bi.* **M. Siegbahn** and **E. Friman.** (Ann. d. Physik, 49. 5. pp. 616–624, April 11, 1916.)—Tables of wave-lengths, relative intensities, etc., of the principal lines in the spectra of the elements Ta, W, Os, Ir, Pt, Au, Hg, Tl, Pb, Bi; Moseley's relation $\sqrt{\nu} = a(N - N_0)$ being verified. [See Abs. 681 (1916) and preceding Abs.] A. B. W.

785. *Spectrum of Röntgen Rays.* **O. J. Zobel.** (Phys. Rev. 7. pp. 580–582, May, 1916.)—In an application of the Fourier analysis to radiation pulses which might result in giving the proper Röntgen spectrum, Sommerfeld [see Abs. 1267 (1915)] compares the relative merits of two types of pulses—the "one-sided" (electric force always of same sign during each pulse) and the "two-sided" (time-integral of electric force equals zero for each pulse). Sommerfeld concludes, "every one-sided pulse has its spectral maximum in the longest wave-lengths. On the other hand, the intensity of the completely 'two-sided' pulse is here always equal to zero. From this it appears that only a 'two-sided' pulse can produce an actual Röntgen spectrum."

This result is now criticised, the author attempting to show mathematically that both types of pulses give the broadest maximum in the spectrum *at exactly the same wave-lengths,* and that the other maxima occur at the same wave-lengths also. Thus he concludes that the "one-sided" pulse does not have its broadest maximum in the very long wave-lengths any more than does the "two-sided" pulse. A. B. W.

RADIO-ACTIVITY.

786. *Energy of Secondary β-Rays Produced by partly-absorbed γ-Rays.* **H. F. Biggs.** (Phil. Mag. 31. pp. 430–438, May, 1916.)—From a consideration of the work of Rutherford and Andrade [Abs. 1543 (1914), 185 (1915)], and of Rutherford, Robinson, and Rawlinson [Abs. 182 (1915)], the question arises as to whether the number of quanta which γ-rays of given frequency may impart to secondary β-particles is independent of the energy of the impinging γ-rays, or whether the γ-rays, when they lose energy in passing through matter, may lose also the power of producing β-rays of great energy —whether, for instance, γ-rays that originally can impart $5h\nu$ to an electron may be able, after passing through 1 cm. of lead, to impart at most the energy $3h\nu$. For it seems probable that in passing through matter γ-rays may lose energy some other way than by the production of β-rays. It is suggested that the scattering of γ-rays investigated by Florance [Abs. 884 (1914)] may be due to the forced vibration of electrons that remain in the atom and therefore absorb less energy than those projected as secondary β-rays. If this is correct, it is to be expected that γ-rays, after passing through a considerable thickness of matter, would be, as it were, shorn of some of their available quanta, and that therefore their secondary β-radiation would be, on the whole, less penetrating than that of the unaffected γ-rays.

The paper describes an investigation of this point. It was found that if this effect of matter on the γ-rays exists, it lies beyond the range of the method used. A. B. W.

787. *Radio-active Fluctuations—using Unsaturated Currents.* **E. v. Schweidler.** (Ann. d. Physik, 49. 5. pp. 594–598, April 11, 1916.)—This consists of observations on a paper of the same title by A. Ernst [Abs. 205 (1916)]. Work of Kohlrausch and of Meyer (Jahrb. d. Radioaktivität, 5. p. 423,

1908) has shown that the mean relative (percentage) fluctuation of the observed ionisation currents is *less* for unsaturated than for saturated currents. The experimental part of the work, undertaken by Ernst [*loc. cit.*], confirmed these striking results. Ionisation fluctuations and conductivity fluctuations are first considered when the ionisation is produced by α-rays. Fluctuations due to recombination of ions are subsequently examined, the mean relative fluctuation being expressed by the relation $\epsilon = 1/\sqrt{(z\delta)}$, where z is the number of α-particles emitted per sec. A. B. W.

788. *A New Element: Brevium.* **O. H. Göhring.** (Jahrbuch d. Mineralogie, ii. Ref. 15, 1915. From Dissertation, Techn. Hochschule, Karlsruhe. Chem. Soc., J. 108. ii. p. 665, 1915. Abstract.)—Uranium X consists of two elements, uranium X_1 and uranium X_2, with half-periods of 24·6 days and 1·15 minutes respectively. The latter is called *brevium*, and finds a place in the fifth group of the last line of the periodic system, being a near analogue of Ta. The transformation scheme of the uranium series is—

$$\underset{6}{U_1} \xrightarrow{\alpha} \underset{4}{UX_1} \xrightarrow{\beta} \underset{5}{UX_2} \xrightarrow{\beta} \underset{6}{U_2} \xrightarrow{\alpha} \underset{4}{Io} \xrightarrow{\alpha} \underset{2}{Ra}.$$

789. *Probable Existence of a Polonium-Hydrogen Compound.* **R. W. Lawson.** (Monatshefte d. Chemie, 36. pp. 845–852, 1915.)—In the author's experiments on the range of α-particles given off by polonium in a hydrogen atmosphere, it was noticed that the ionisation current at a given distance from the source of the rays increases slowly with time. The suggestion is now put forward that a volatile compound of Po and hydrogen is formed, such compound being quickly decomposed by ionised oxygen. L. H. W.

790. *Radio-activity of Allanite.* **L. S. Pratt.** (Am. Inst. Mining Eng., Bull. 113. p. 865, May, 1916. Met. and Chem. Eng. 14. p. 484, May 1, 1916.)—A rough comparison has been made between the radio-activity of allanite and the following feebly radio-active substances: uranium nitrate, Nernst mantle, thorianite, and radium residue. It was found that the ionisation produced by a sample of allanite was about one-eighth that of the Nernst mantle and one-fifth that of the same quantity of uranium nitrate. A. B. W.

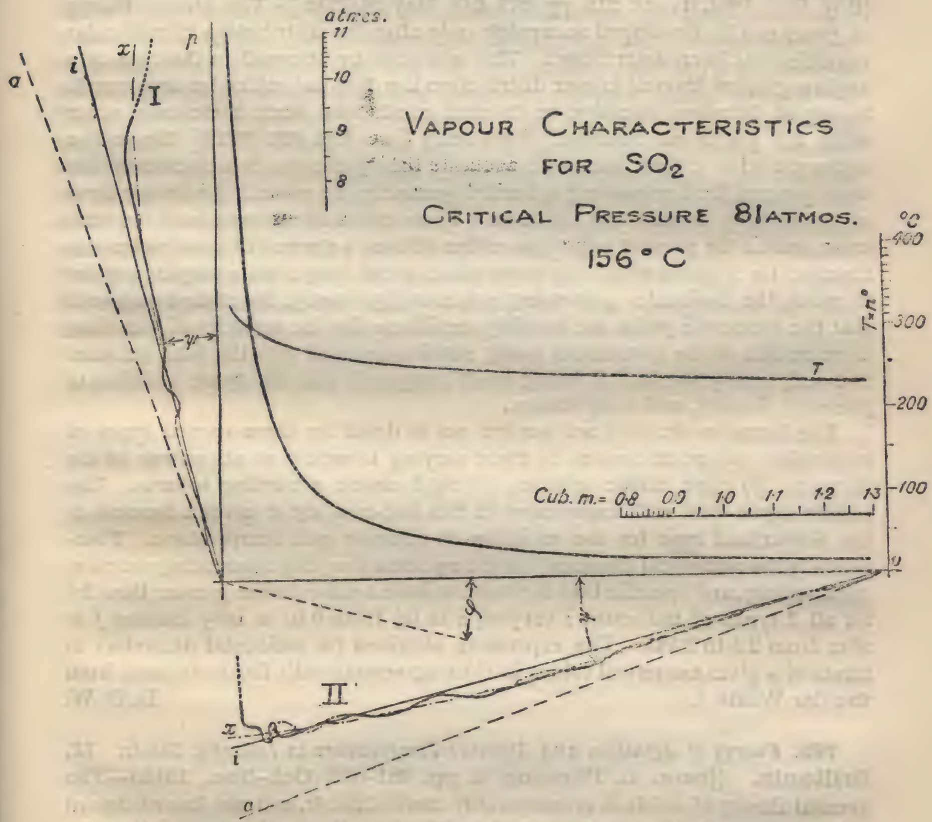
HEAT.

791. *Diathermancy of Liquids.* **J. Vallot.** (Comptes Rendus, 162. pp. 504–506, April 3, 1916.)—The author has shown [Abs. 1696 (1915)] that errors in the determination of the diathermancy of liquids due to reflection, etc., at the end-plates of the containing vessel could be eliminated by measuring the absorption produced by a capillary layer between the plates. The method fails in the case of thick and syrupy liquids, for which it is impossible to obtain layers of sufficient thinness, and also for liquids having strong absorption bands. In these cases it is shown how the end-plate error can be allowed for by making use of the fact that the absorption produced by plates and capillary layer is inversely proportional to the difference between the refractive indices of the liquid and the plates. This statement has been verified by observations on some 40 colourless liquids, using optically worked quartz plates. D. O. W.

792. *Influence of Pressure on the Combustion of Explosive Gas-Air Mixtures.* **E. Terres** and **F. Plenz.** (J. für Gasbeleuchtung, 57. pp. 990–995, 1001–1007, 1016–1019, 1914.)—The influence of pressure on the explosive limits of mixtures of hydrogen, CO, and methane with air, and on the processes of combustion has been investigated by estimations of the products of the reactions. Increase of the initial pressure restricts the region of explosion, particularly with the mixtures containing CO; the upper limit of explosion of methane furnishes, however, an exception to this rule. The explosion limit is by no means a sharply defined region, diminishing concentration leading gradually from the region of explosion through one of decreasing partial combustions to mixtures which do not ignite. With hydrogen and methane, such partial combustions are lacking at the upper limit of explosion. The explosive limits are defined as the concentrations of combustible gas at which the heat developed in unit time exactly covers the loss, so the combustion either just does or just does not proceed through the mixture. With rise of temperature these limits are extended. As regards the ignition, it is found that no essential difference exists between ignition by heating and ignition by a spark; the locality of the ignition does, however, exert a marked influence on the value of the partial combustions. T. H. P.

793. *Characteristic Curves for CO_2, SO_2, NH_3, and Steam.* **B. Leinweber.** (Zeits. Vereines Deutsch. Ing. 60. pp. 363–366, April 20, 1916.)—Hitherto no analytical equation has been discovered, making it possible to determine corresponding values of p and v for dry saturated vapours. The law $pv^n = C$ is approximately true for permanent gases (*i.e.* very highly superheated vapours) but even then the index n is not absolutely constant. The author attacks the problem by drawing the p, v curve for dry saturated vapour from published tables and thence deriving the "diagram characteristic" [see also Abs. 701 (1913), 131 (1914)] which shows at once the index n (in $pv^n = C$) corresponding to each point on the "condition curve" p, v. The value of n is not constant, but may be expressed as a function of p (or v). The characteristic curves show clearly the effect of any error in the tabular values of p, v (which are often interpolated); suitable allowance is easily made for this and mean

characteristics are obtained from which the mean values of n are calculated. The primary p, v curve, the characteristic curves I, II, and the mean curves (dotted) for SO_2 are shown in the Fig. Similar curves are given for CO_2, NH_3, and steam. The critical pressures are: CO_2, 75 atmos., 31° C., SO_2, 81 atmos., 156° C.; NH_3, 115 atmos., 130° C.; steam, 205 atmos., 365° C.; and it is shown that at low pressure and temperature the exponent of the "condition line" is practically constant. Mean values are: $n = 0{\cdot}94$ up to 22·8 atmos. for CO_2; 1·06 up to 0·38 atmos. for SO_2; 1·0 up to 0·95 atmos. for NH_3; and 1·074 up to 0·35 atmos. for H_2O. At higher pressures, except in the case of CO_2, the exponent varies within wide limits and according to a wavy characteristic.



The mean curve x is curved for SO_2 (see Fig.) and yet more curved for CO_2 (almost parabolic in the neighbourhood of the critical pressure); but for NH_3 and H_2O it is practically a straight line, corresponding to $n = 1{\cdot}07$ and 1·1 respectively. The critical pressure is low for SO_2, lower for CO_2, but much higher for NH_3 and water. In other words the line x is straight for critical pressures above a value lying between 81 and 115 atmos. and for lower pressures becomes more curved the lower the critical pressure, at any rate where the present four vapours are concerned. In order to obtain an equation for the condition curve p, v, it is necessary to set $n = f(p) + F(p)$, where $f(p)$ is such a function that it gives the curved line x for vapours with low critical pressure, on being substituted in the formula $(1 + \tan\psi) = (1 + \tan\phi)^{f(p)}$. The

term F (p), on the other hand, is a high cyclic function imparting to the characteristic its oscillations about the mean line x. Then for vapours with high critical pressure, $n = c + F(p)$, where c is a constant. Before the values of $f(p)$, F (p) can be usefully evaluated it is necessary to determine more accurately tables giving actual p, v values for vapours. Variations in n for steam are not sufficient to make correction necessary in constructing expansion characteristics for indicator diagrams. R. E. N.

794. *Law of Distribution of Molecular Velocities, and Theory of Viscosity and Thermal Conduction in a Non-uniform Simple Monatomic Gas.* **S. Chapman.** (Roy. Soc., Phil. Trans. 216. pp. 279–348, May 26, 1916.)—The kinetic theory of gases can be developed accurately only after the distribution of molecular velocities has been determined. This was done by Maxwell in the case of a *uniform* gas, but his well-known distribution law does not suffice for an accurate theory of diffusion, viscosity, or thermal conduction since these only occur when the gas is *not* uniform. Previously [see Abs. 636 (1912)] the author endeavoured to extend Maxwell's accurate theory of a gas to molecules of this most general kind possessing spherical symmetry, by assuming a simple form of the velocity distribution function. These calculations were only approximate, and in the present paper the author obtains a general expression for this function for a gas in which the mean velocity and temperature vary from point to point, the molecules possessing spherical symmetry, the state being such that the molecular paths are sensibly rectilinear for the majority of the time, the duration of the encounters being small compared with the time between two and, finally, the M.F.P. being *small* compared with the space variation of pressure, density, and temperature.

The formulæ obtained are worked out in detail for three special types of molecules: (*a*) point centres of force varying inversely as nth power of the distance, (*b*) rigid elastic spheres, (*c*) rigid elastic attracting spheres. The results agree best with experiment in this last case, *e.g.* it gives a formula of the Sutherland type for the variation of viscosity with temperature. Theoretically the numerical constant f in the equation $\mu = f\vartheta C_v$ connecting viscosity, conductivity, and specific heat is shown to have a value rather greater than 2·5 for all 3 types of molecules; varying n in (*a*) from 0 to ∞ only causing f to alter from 2·5 to 2·525. The expression obtained for molecular diameters in terms of μ gives numerical values in close agreement with those obtained from van der Waals' b. D. O. W.

795. *Energy of Agitation and Absolute Temperature in Isotropic Solids.* **M. Brillouin.** (Journ. de Physique, 4. pp. 681–699, Oct.–Nov., 1914.)—The general theory of solids is incomparably more difficult, and our knowledge of it less advanced, than that of fluids. The hypothesis of Clausius, that the kinetic energy of one gm.-molecule (or more exactly of one degree of freedom of this gm.-molecule) is proportional to the experimental absolute temperature, is not at all applicable to the case of a solid. Proceeding on the lines of classical thermodynamics, combined with modern ideas of "black" radiation, but without anywhere introducing the notion of "quantum," the author deduces formulæ, giving the connection between the thermodynamic potential and the general properties of an isotropic solid body. The energy of molecular agitation of a gm.-molecule is shown to be given by the product of a "universal function" (involving the velocities and frequencies of the waves in the ether and material medium, together with the density of the energy) and the quantity $MV/2\omega_1^3$, in which V is the volume of the molecular mass M,

and ω_1 the velocity of the elastic wave in the solid medium. A similar formula gives the energy of rotation of the gm.-molecule. This relation is seen to be very far removed from that which holds in the case of a simple gas. Various simplifications are shown to be possible in particular cases.

T. B.

796. *Entropy of Solid Solutions.* **O. Stern.** (Ann. d. Physik, 49. 7. pp. 823–841, May 11, 1916.)—The author gives a general theory of solid solutions based on the assumption that, in a mixed crystal, the molecules of the components are arranged in equilibrium layers with a space-lattice structure, and are able to interchange their positions by diffusion. All possible arrangements of the crystal are obtained by distributing the different kinds of molecules in all possible ways over the lattice, and each of these arrangements represents a definite chemical compound isomeric with all the others. The probability of a selected arrangement and the entropy of the solution are obtained with the help of the theory of chemical equilibrium, and this gives general formulæ for the free energy and specific heat. The value of the entropy approached at high temperatures agrees with that obtained from the classical theory, but it is not zero at the absolute zero of temperature unless *one* arrangement *only* has a smaller free energy than all the others. This is the condition for Nernst's theorem (that the entropy tends to zero as the temperature decreases) to hold. If more than one arrangement has this same minimum amount of energy the Nernst theorem does not hold good.

D. O. W.

SOUND.

797. *True Nature of Speech.* **J. B. Flowers.** (Am. I. E. E., Proc. 35. pp. 183–201, Feb., 1916.)—From experiments showing that speech is the result of action of the mouth-parts in varying the intensity of the voice and mouth-tones, and through photographs taken with the string galvanometer of each letter sound of the alphabet, it is concluded that speech is a rapid variation in intensity of the voice and mouth-tones according to definite sound patterns called letters of the alphabet. From the photographic vibration records the phonographic alphabet is obtained by measuring the variations in intensity of the main tone of the record.

The precise meaning will be clearer if illustrated by an example. Thus, if a tone of, say, 1000 cycles per sec. commences softly, increases considerably in loudness reaching a maximum in about 1/150 sec., decreasing to about half the amplitude in the next 1/150 sec., then very slightly increasing and decreasing in the next 1/150 sec., it is claimed that the sound of *b* is heard. No matter what the pitch, provided the fluctuations of loudness follow this law and are included in about 1/50 sec., it is asserted that the sound of *b* is recognised. Thus, in the fiftieth of a second, we may have 20 vibrations at a frequency of 1000, or only 5 vibrations at a frequency of 250.

A design for a voice-operated phonographic-alphabet writing machine is also described. The object of this device is to record speech automatically in ink on paper in the form of an easily read compact system of natural characters called the phonographic alphabet. Its design comprises a high-power telephone transmitter controlling electric resonator circuits, the intensity of currents in which is measured by the vibration of mirrors reflecting light upon a selenium cell connected to a special recording pen.

E. H. B.

798. *Sub-Helmholtzian Vibrations of a Rubbed String.* **H. Clark.** (Phys. Rev. 7. pp. 561–579, May, 1916.)—The problem of the longitudinal vibration of a rubbed string has been extensively studied by Davis [Abs. 1261 (1906)], to whom it was suggested by its usefulness in the study of the effects of mechanical stress upon the magnetic properties of materials. The present author undertook a further study of the subject with a twofold purpose: first, of determining more carefully the conditions necessary for the production and accurate duplication of the various wave-forms with unfailing regularity; and second, of studying in detail particular conditions of rubbing hitherto uninvestigated.

A satisfactory solution of the first of these problems is due largely to the adoption of a new rubbing device whose action is extremely uniform and reliable. This was a silk-covered brass wheel wetted with alcohol and rotated by an electric motor. The second problem refers to the so-called sub-Helmholtzian vibrations which, under favourable circumstances, may be produced by rubbing with slight pressure. They are of small amplitude and were photographically recorded, six reproductions being given in the paper.

E. H. B.

799. *Variation of Sound Intensity with Distance.* **G. W. Stewart.** (Phys. Rev. 7. pp. 442–446, April, 1916.)—A continuation of previous work as to the departure of sound intensity from the law of the inverse square of distance when the origin is a small area in the surface of a rigid sphere, to which the human mouth is assimilated.

The results are now applied to hearing by use of the reciprocal theorem of Helmholtz, and are shown in tables. [See Abs. 1716 (1915).] E. H. B.

800. *Resonance Theory of Audition due to Helmholtz in agreement with the Acoustical Phenomena referred to as Reflection or Pfaundler Tones.* **F. A. Schulze.** (Ann. d. Physik, 49. 6. pp. 683–709, May 5, 1916.)—An experimental research in which a number of tones were examined and the results, as favouring the resonance theory or the periodic theory, given in tables occupying five pages. The chief results may be summarised thus :—For the regular intermittances or fluctuations of intensity or regular phase-changes of a primary given tone, also for the so-called reflection tones or Pfaundler tones, and again for the related Seebeck tones, what is heard, contrary to earlier observations, is not in agreement with the periodic theory of audition, but, on the other hand, is in all details in perfect agreement with the *resonance theory of audition and confirms it.* The ear always behaves in these cases as a set of resonators in the sense of the conceptions of Helmholtz. Hence there are no reflection tones, just as there are no intermittent tones and no phase-change tones. [See Abs. 332 (1915).] E. H. B.

801. *Pressure of Sound Waves.* **E. P. Lewis.** (Science, 43. pp. 646–648, May 5, 1916.)—In his "Heat Radiation," Planck, after proving from electromagnetic theory that the pressure of radiation equals the volume density of radiant energy, shows that the corpuscular theory of light would give a pressure twice as great. From this he infers that the Maxwell radiation-pressure cannot be deduced from energy considerations, but is peculiar to the electromagnetic theory and is a confirmation of that theory. The implied conclusion is that mechanical waves would not exert a pressure of this magnitude. It is then recalled that Rayleigh has shown, from energy considerations, that transverse waves in a cord exert a pressure equal to the linear energy-density, and that sound waves in air must cause a pressure equal to the volume density of energy in the vibrating medium.

As the pressure due to sound waves in a gas must be ultimately the result of molecular impacts, it would seem probable that the magnitude of this pressure may be determined from the elementary kinetic theory; and this proves to be the case. The following is an outline of the author's method. Let U^2 be the mean square of the translational velocity normal to the surface in question and let u^2 be the mean square of velocity in the same direction due to wave displacement. Then total pressure on surface is—

$$Nm\,(U \pm u)^2 = Nm\,(U^2 + u^2),$$

since on the whole $\pm 2Uu$ is zero. But, apart from the waves, the gas pressure would be NmU^2, which leaves as pressure due to the sound waves $Nmu^2 \ldots (1)$. But this is the volume density of wave energy. For if the waves are $a \sin \omega\,(t - x/v)$, the volume density of energy is—

$$\tfrac{1}{2}\rho a^2\omega^2 = \rho u^2 = Nmu^2 \ldots (2).$$

[See Abs. 1495 (1902) and 1471 (1904).] E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

802. *Electrodynamics of Dielectrics.* **P. Duhem.** (Comptes Rendus, 162. pp. 282–286, Feb. 21, 1916.)—Expressing the total electric field in the known form $\zeta = \partial\Phi/\partial x + \partial Q/\partial z - \partial R/\partial y$, $\eta = \partial\Phi/\partial y + \partial R/\partial x - \partial P/\partial z$, $\zeta = \partial\Phi/\partial z + \partial P/\partial y - \partial Q/\partial x$, the author shows that within any dielectric the equation $\partial^2 V/\partial t^2 - 4\pi K . \partial^2\Phi/\partial t^2$ is satisfied, where K is the polarisation coefficient. This equation negatives the author's former assumption (Archives Néerlandaises, p. 227, 1901) that in the transmission of plane waves across the common surface of two dielectrics, the component along the surface, of the longitudinal field, has no discontinuity at the surface, and shows that when an assumption is needed for determination, the true one is, for simple harmonic waves, that it is not the component along the surface of the longitudinal field that varies continuously, but K times the component. Further, it is shown that, in a medium consisting of two or more dielectrics, the electric field cannot be entirely longitudinal. G. W. DE T.

803. *The Law of Electromagnetic Induction.* **L. Lombardi.** (Elettrotecnica, 3. pp. 286–295, May 15, 1916.)—A discussion which took place lately upon the exact enunciation of the law of electromagnetic induction and upon the interpretation of some experiments, the purpose of which was to demonstrate that the common enunciation of this law was incomplete, if not incorrect, leads the author to consider this argument. Starting from Faraday's experiments and conceptions, the author shows that in all cases the value of the e.m.f. induced in a conductor is the sum of the elementary e.m.f.'s induced in each element of it by the number of tubes or lines of magnetic induction cut in unit time. This is the exact manner of enunciating the law of magnetic induction. But, on the other hand, the consideration of the variation of the magnetic flux through a closed circuit leads to a considerably simpler calculation of the integral e.m.f. generated in the circuit. This form of enunciation of the law of the electromagnetic induction is then of practical interest only, but it does not answer to a physical conception. It, therefore, must be applied only in those cases that fulfil the conditions in which the experiments of Faraday, from which it was originated, were made. These conditions are that the induced circuit be always closed, that its form be not changed, and that no brushes or sliding contacts be employed.

The author discusses Hering's experiments [Abs. 838 (1908)] and also Blondel's, and describes an apparatus devised by himself for the same purpose; the apparatus is similar to that of Blondel, but more general. E. B.

804. *Mobilities of Ions produced by spraying Distilled Water.* **J. J. Nolan.** (Roy. Irish Acad., Proc. 33. pp. 9–23, May, 1916.)—Previously the author has investigated the electrification given to distilled water by breaking it up in contact with air [Abs. 1702 (1914)]. The water takes up a positive charge

proportional to the area of new water-surface produced; the negative charge is carried off in the air, which contains ions of both signs with negative in excess. The author now investigates the mobilities of these ions. The coaxial cylinder method of measurement is used, in which the ionised air is drawn at a steady rate from the spraying chamber between the cylindrical electrodes and a current-voltage curve is plotted. If a number of different classes of ions is present, each class having definite mobility, the curve is made up of a number of straight lines, the final line being parallel to the axis of voltage. Each intersection represents a voltage at which one class of ion is saturated, and the mobility is given by $V = \log_e(b/a)Q/2\pi Lu$, where V is the saturation voltage, a and b are the radii of the inner and outer cylinders, Q is the quantity of air drawn through per sec., L the length of inner cylinder, and u the mobility. The author summarises his results as follows:—Twelve classes of ions exist having mobilities of 0·00038, 0·0010, 0·0043, 0·013, 0·46, 0·12, 0·24, 0·53, 1·09, 3·27 and 6·5 cm./sec. per one volt/cm. These are found carrying both positive and negative charges except the fastest, which has not been found with a positive charge. There is no change of mobility with time within a considerable range. The negative ions exceed the positive in the ratio of 5/4 for the slower ions, varying to 2/1 for the faster groups. Certain mobilities occur that do not fit in with any of the above, which tends to weaken the idea of groups. Nevertheless the group system is held to be well established for the slower ions and hardly less so for those more mobile. Further investigation by a more accurate and rapid method should clear up the point. [See next Abstract.] T. H.

805. *Nature of the Ions produced by bubbling Air through Mercury.* **J. A. M'Clelland** and **P. J. Nolan.** (Roy. Irish Acad., Proc. 33. pp. 24–34, May, 1916.)—In this work the mobilities of the ions carried away by air bubbled through mercury are examined. The method adopted is similar in principle to that described in the preceding Abstract. The mobilities are found to vary with the time: the longer the time that elapses between bubbling and measurement, the smaller the mobilities. With sufficient time, the mobilities reach steady values. The slowest ion finally reaches the same mobility as the large Langevin ions found in the atmosphere, and in flame gases which have been allowed to cool, and apparently there is no further decrease. Measurements were therefore made (1) allowing time for the minimum values to be reached using undried air; (2) similarly, using dried air; (3) as soon as convenient after the bubbling, using undried air; (4) similarly, using dried air. Five sets of ions are shown to exist in all four cases. The mobilities in case (1) are smaller than those in case (2), and similarly those in case (3) are smaller than in case (4); but the ratios of the mobilities of the ions in the different groups are approximately the same in all cases.

The variation of mobility with time is explained as due to the mercury ions gradually adding on water-vapour before arriving at a stable condition. When the air is "dried" the approach to stable conditions is retarded by the diminution of vapour present.

The mobilities of the five stable sets of ions found when using undried air bubbled through mercury correspond closely with those of the five slowest groups found in the preceding work, using air from sprayed water; and in a joint discussion of the results with the author of the preceding paper these groups alone are dealt with. Amongst various possibilities the authors put forward the suggestion that there is one stable size of water globule to which a charge is attached, and the five different ions consist of groupings of

different numbers of these globules. Before the steady state is reached each globule is taking on water, and therefore the grouping which constitutes an ion is growing at a rate depending on the number of globules it contains. The constancy of the ratio of mobilities is at once explained on this theory. According to this view ions of each class combine to form the next slower class, and, given sufficient time, an excess of the most complex ion would be obtained. The percentage of slowest ion present does increase with time, but it is uncertain whether this may not be sufficiently explained by the more rapid loss of the more mobile ions through recombination. T. H.

DISCHARGE AND OSCILLATIONS.

806. *Ionisation and Dissociation of Hydrogen Molecules and the Formation of H_3.* **A. J. Dempster.** (Phil. Mag. 31. pp. 438–443, May, 1916.)—By the analysis of positive rays J. J. Thomson has shown that in a discharge-tube containing hydrogen there are present charged atoms, charged molecules, and sometimes a constituent with a mass three times that of the atom of hydrogen. In the present investigation a different method of obtaining the positive rays was used, accelerated electrons from a Wehnelt kathode being employed for this purpose. Combined electric and magnetic fields deflect the positive particles through a parabolic slit into a Faraday measuring chamber. It is found that electrons of 800 volts velocity ionise hydrogen by detaching a single elementary charge from the molecule. They are not able to dissociate the gas. The positive molecules so formed *are* able to dissociate the gas. When this occurs the complex H_3 is formed. H_3 cannot be regarded as a stable gas, since it is not present when there is no dissociation of the hydrogen molecules. A. B. W.

807. *Photoelectric Discharge from Leaves.* **J. A. McClelland** and **R. Fitzgerald.** (Roy. Irish Acad., Proc. 33. pp. 1–8, May, 1916.)—Leaves of sycamore, chestnut, grass, chrysanthemum, and others were placed on an insulated support in a metal vessel, the lid of which was a quartz window, with metal gauze underneath, through which ultra-violet light was passed. The tray containing the leaves was joined to an electrometer, and the metal vessel to a source of 240 volts. The max. effect from a leaf (sycamore, chrysanthemum) was about 10 % of that from the same area of copper. Acetone solutions of chlorophyll are inactive, but a very active precipitate is obtained by diluting them largely with water. With warm distilled water an extract can be obtained which is half as active as copper. The results are taken as showing that the emission of electrons under ultra-violet light is facilitated by chemical change, more especially as oxidising agents greatly increase the activity. E. E. F.

808. *Absorption of Gas by Quartz Vacuum Tubes.* **R. S. Willows** and **H. T. George.** (Phys. Soc., Proc. 28. pp. 124–130 ; Disc., 130–131, April, 1916.)—The experiments are a continuation of those of Willows [Abs. 1513 (1901)] and Hill [Abs. 486 (1913)] on the absorption of gas which is brought about by electrical discharges. A new quartz bulb does not absorb air, but if it be fed with repeated doses of hydrogen—which are absorbed when an electrodeless discharge is passed—it then becomes very active. If discharges in hydrogen are alternated with those in air the bulb can be made to absorb large quantities of either gas, and the activity with each gradually increases.

The authors reject the theory of surface absorption, and, in their own experiments at least, also Swinton's theory that the gas is shot into the walls and held there. It is supposed that chemical actions occur with air, and oxidation products are formed ; these are reduced by hydrogen. The process is compared with the formation of the plates in a Planté cell ; the absorption of hydrogen corresponding to the charging, and that of air to the discharging of the cell. Attempts to produce the same effects by chemical treatment were partially successful, particularly in fatiguing the bulb so that no further absorption took place. The conditions under which the primary and secondary hydrogen spectra appear are also described. AUTHORS.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

809. *Light-sensitiveness of Selenium Crystals.* **K. J. Dieterich.** (Phys. Rev. 7. pp. 551–560, May, 1916.)—Selenium crystals of the hexagonal, acicular, and monoclinic lamellar types were illuminated in a direction perpendicular to the long axis, and a current was passed through them at right angles to the light by means of Pt-electrodes pressed against them by a weight. It was found that the resistance decreases with increase of temperature, with a small increase in some cases between 0° and 50° C. The theory now adopted is the ionisation theory [see Abs. 209 (1914), 902 (1915)]. It is found that the coefficient of recombination decreases with increase of temperature in much the same manner as it does in gases.

Over a wide range of temperature the rate of initial recovery is proportional to the conductivity in the light. The sensitiveness to light does not vary greatly with temperature, though a maximum is indicated between 30° and 50° C. E. E. F.

810. *Mutual- and Self-induction of Circular Coils.* **S. Butterworth.** (Phil. Mag. 31. pp. 276–285, April, 1916.)—Expressions are obtained for the mutual induction of coaxial circular coils and for the self-induction of solenoids. The formulæ are given in the form of infinite series, and apply to the case in which the circles are close together. Formulæ previously given hold for the case in which the circles are far apart. [See Abs. 914 (1915).] A. J. M.

811. *Mutual Induction of Eccentric Coils.* **S. Butterworth.** (Phil. Mag. 31. pp. 443–454, May, 1916.)—In certain types of variable inductances, one coil moves so that its plane remains parallel to, and at a constant distance from, the plane of a fixed coil. This leads to the problem of determining the mutual induction of two circular coils in parallel planes, the coils not being coaxial. Formulæ are given for such coils, the results being worked out in tables for some special cases. A. J. M.

812. *Electrical Capacity of Gold-leaf Electroscopes.* **T. Barratt.** (Phys. Soc., Proc. 28. pp. 162–170 ; Disc., 170–171, April, 1916.)—A gold-leaf electroscope is frequently used to compare exceedingly small ionisation currents. For this purpose it is much more sensitive than a quadrant electrometer. If the capacity of the electroscope is known, then the absolute value in amps. of the ionisation current can be deduced. A method is described for measuring the capacity of a gold-leaf electroscope, the method depending

on sharing the charge of a parallel-plate air condenser of measurable capacity as many times as necessary, and deducing the capacity of the electroscope from the observed drop of potential. The method gives consistent results when the experimental conditions are widely varied. The amount of deflection of the leaf appears to have little influence on the result. AUTHOR.

813. *Specific Resistance and Optical Constants of Thin Metal Layers.* **B. Pogány.** (Ann. d. Physik, 49. 5. pp. 531–568, April 11, 1916.)—The metals used in the research here described were Pt, Pd, Au, and Ag, in layers whose thickness varied from 1 to 100 $\mu\mu$. The specific conductivity, the refractive index (n), and the absorption index (k) were determined as functions of the thickness of the layer. The respective curves, which express these quantities as functions of the thickness, are of the same type for each of the metals dealt with. The variation of n and k with the thickness is seen to be a parallel phenomenon with the rapid variation of the specific conductivity. Planck has determined the values of n and k for thin copper layers as functions of the thickness, and his curves are of the same type as those here given. The latter part of the paper contains a discussion of the results in the light of the dispersion theory. A. W.

814. *Resonance Method for the Determination of the Dielectric Constants of Conducting Dielectrics, also for the Measurement of the Phase Factors of Rheostat Resistances.* **F. Tank.** (Phys. Zeits. 17. pp. 114–117, April 1, 1916.)—Based on the property that the resonance of a parallel installed self-inductance and capacity can be made independent of a parallel resistance, and with the aid of Sumpner's electrodynamometer as a resonance recording instrument [see Abs. 235 (1916)], a method has been devised for measuring the capacities of condensers with conducting dielectrics. The sensitiveness is at least equal to that obtained by the Nernst method. The process also admits of measuring the capacity of self-inductances, and for the determination of the phase factors of rheostat resistances. Very full details are given in the paper.
H. H. Ho.

815. *Propagation of Electricity through Paraffin Oil.* **G. G. de Villemontée.** (Journ. de Physique, 4. pp. 770–786, Dec., 1914. Paper read before the Soc. franç. de Physique.)—The present investigation is a continuation of previous work [Abs. 1444, 1445 (1914)] on the propagation of electricity through liquids which are poor conductors, the special subject here being paraffin oil of density 0·876 at 24° C. The liquid was placed between two brass cylinders so arranged as to be concentric. The external wall was charged in various ways, viz. by Gouy elements, Daniell cells, and accumulators. A zero method was employed to measure the amounts of electricity which pass through to the inner wall. The first part deals with charges of long duration, when the potential is maintained constant between the two armatures. The variations of the ratio p/Vt have been studied, where p is the weight, t the time, and V the potential, and curves are given showing these variations as a function of the time. When the curve has for coordinates $\log_e t$ and $\log_e p/Vt$ it is found to consist of a rectilinear part followed by an inflected curve and then another rectilinear portion of slight inclination. For the rectilinear portion, $p/Vt = e^b t^{-a}$, where e is the logarithmic base and a and b are constants. The law of the variation of the ratio p/Vt is independent of the condenser dimensions. The author has confirmed a previous law

of e.m.f.'s, viz. "The quantities of electricity disengaged at the internal wall of the condenser after equal charging intervals are proportional to the p.d.'s, *i.e.* to the e.m.f.'s." A comparison is made between the observed facts with paraffin oil and results obtained with solid dielectrics. The only differences are in the speed of the variations. The law has been found true when the external plate is maintained at a constant potential and the internal one insulated.

The second part of the paper deals with charges of very short duration, and with phenomena occurring at the initiation of the charges. The total charges disengaged on the internal plate by charges of short duration on the external, and also those disengaged on the internal plate during the charging intervals on the external, are investigated. A sudden charging of the external plate produces a sudden charge on the internal, and this charge is followed by a slow electrical development during the fractions of a second following the instantaneous charge.

The third part deals with the relationship between the charges of the external and internal walls, while the fourth part considers the influence of the thickness of the dielectric, during charges of extremely short duration, and also during extended intervals. The author finds that the ratio of the charges on the inner plates of two condensers varies in the same sense with the duration of charge on the external plate. In conclusion, the author states that the laws of the propagation of electricity through paraffin oil are the same as those established by Curie for electrical propagation through crystalline bodies. The paper abounds in experimental data accompanied by suitable illustrations. H. H. Ho.

816. *Thermal E.M.F.'s and Resistances of Bad Conductors.* **A. Weissenberger.** (Ann. d. Physik, 49. 5. pp. 481–530, April 11, 1916. Dissertation, Freiburg.)—The e.m.f.'s and resistances of Nernst and Auer rods, quartz, glass, magnesia, and certain silicates have been measured by the author. The Nernst and Auer rods give values of the same order, but the former shows a decrease in e.m.f. towards lower temperatures, while the latter shows an increase. On account of the high e.m.f. of the Nernst rod the Peltier-effect could be observed optically. The other substances also gave high e.m.f.'s. The experiments indicate that the conduction in Nernst and Auer rods is essentially metallic. The behaviour of glass is more complex and gives indications of being partly metallic and partly electrolytic. The e.m.f. of the Auer rods follows a formula due to Baedeker, but that of the Nernst rods does not. In the theoretical part of the paper the author discusses the bearing of these results on the electron theory. I. W.

817. *Variation of Manganin Resistances with Atmospheric Humidity.* **J. Obata.** (Math. Phys. Soc. Tōkyō, Proc. 8. pp. 394–400, March, 1916.)—Over a period of 18 months the variations of 11 manganin resistance standards were observed. Standards of low denomination varied in a manner similar to that observed by Rosa and Babcock, while those of higher denomination decreased considerably in summer. The cause of this is believed to be the leakage due to condensed moisture. The seasonal variation of the coil was, in both cases, far smaller than that observed at Washington. The constancy of sealed resistances is satisfactory even in the very damp atmosphere of Japan. F. E. S.

ALTERNATING CURRENTS AND MAGNETISM.

818. *Change of Length in Nickel Wires due to Transverse Magnetic Fields.* **W. Brown.** (Roy. Dublin Soc., Proc. 15. pp. 121–124, May, 1916.)—Experiments were made with soft nickel wire by subjecting it to the influence of transverse magnetic fields both direct and alternating. These fields were produced in a gap formed of soft-iron tube by means of five insulated copper wires inside the tube, the return wires of the circuit being 200 cm. distant. The strength of the magnetic field in the gap was proportional to the total current through the wires. The tube with the wires inside was fixed vertically against a wall and the Ni-wire under test was suspended in the middle of the gap from a separate support. The length of the tube was 215 cm., and that of the Ni wire 225 cm. The load on the wire was applied by means of a brass cylinder 1·2 cm. in diameter. The Ni-wire was 0·169 cm. in diam., its rigidity 708×10^6 gm./cm.^{2} and the load attached was equivalent to 2×10^5 gm./cm.^{2}. The wire was subjected to direct transverse magnetic fields up to a max. value of 1000 units and to alternating transverse magnetic fields of max. value 200 units. The following conclusions were obtained from the results: (1) For both direct and alternating transverse magnetic fields a nickel wire expands to a maximum, and then diminishes gradually for high fields. (2) The max. expansion for both direct and alternating transverse fields takes place in the same field-strength of about 50 units. J. J. S.

819. *Subsidence of Torsional Oscillations of Nickel and Iron Wires in Transverse Magnetic Fields.* **W. Brown.** (Roy. Dublin Soc., Proc. 15. pp. 99–106, April, and pp. 125–136, May, 1916.)—The transverse magnetic fields were produced in a soft-iron tube as already described [preceding Abs.]. The apparatus was similar to that previously used, and the first wire tested was a No. 16 soft Ni-wire of simple rigidity about 708×10^6 gm./cm.^{2}. Observations on the subsidence of torsional oscillations were taken for many values of transverse magnetic field up to a maximum of 800 c.g.s. units, both direct and alternating of frequency 50 per sec., and the shape of the subsidence curves was obtained in various cases by plotting the number of vibrations as abscissæ and as ordinates the corresponding value of the amplitude of oscillations. From the results obtained it appears that with a soft Ni-wire both the direct and alternating magnetic fields increase the damping of torsional oscillation. The amplitude of the 70th oscillation is decreased by about 14 % by the application of a direct transverse magnetic field of strength 800 units, and by about 22 % by an alternating transverse field of the same strength and of frequency 50 per sec. It was found that when magnetic fields (of 250 units) at different frequencies are applied the damping of the torsional oscillations is decreased as the frequency is increased. For a frequency of 200 per sec. the application of the field produced an increase of amplitude of the 70th oscillation of about 4 %. When the frequency was increased 8 times the amplitude was increased about 23 %. When a hard wire was used instead of the soft wire the application of the alternating transverse magnetic field of 800 units and frequency 50 caused a decrease of the amplitude of about 30 %, as compared with 22 % for the soft wire. The rigidity of the hard wire was about 810×10^6 gm./cm.^{2}. When tested in fields of varying frequency, and strength 250 units, the damping of the torsional oscillations in the case of the hard wire is decreased, but not so much as in the case of the soft wire. With frequency 25 the damping was

decreased nearly 9 % as compared with nearly 16 % for the soft wire. On increasing the frequency of the field 8 times the damping of the oscillations decreases 6 % for the hard wire and 23 % for the soft wire. A No. 16 iron wire of rigidity 780×10^6 gm./cm.^{2} was put through the same series of tests as the nickel wires. The damping of the oscillations was slightly increased by the application of a direct transverse magnetic field of 200 units, and an alternating field produced a decrease of amplitude of about the same amount as in the case of the soft Ni-wire. With iron wire tested at different frequencies of field the behaviour is different from that of nickel: the damping of the torsional oscillations is slightly increased as the frequency is increased. The application of transverse magnetic fields, direct and alternating, to a comparatively short iron wire has a marked effect. The 70th oscillation is decreased by about 36 % by a direct field of strength 800 units. On applying alternating fields of strength 250 units and of four different frequencies to the short iron wire it was found that increase of frequency caused increase of damping of the torsional oscillations. The amplitude of the 70th oscillation is decreased by nearly 13 % when the frequency of the field is increased 8 times, and the amplitude is decreased nearly 30 % in a field of strength 250 and of frequency 200 per sec. J. J. S.

820. *Magnetic Particles and Rotating Particles.* **A. Korn.** (Phys. Zeits. 17. pp. 112–114, April 1, 1916.)—The old assumption that magnetic particles possess a mechanical rotation about the magnetic axis has won considerable probability from recent experiments. Earlier there was only the argument that the magnetic and rotation axes of the earth were near together, and the phenomenon of the electromagnetic rotation of the plane of polarised light to support the above view. The recent work of Einstein and Haas shows that by the periodic demagnetisation of a magnetisable bar, an actual periodic mechanical rotation moment comes into existence, while Barnett's experiments prove that magnetisable bars may be magnetised when rapidly rotated. If Ampère's theory be applied, an unsymmetrical behaviour of the positive and negative electric particles must be assumed, and many physicists hold the view that the positive particles are at rest in the molecular stream while the negative execute a circular movement about the positive nucleus. Other views are also discussed. The present author here continues work begun in 1898, upon the connection between magnetism and mechanical rotation. According to his view, at every point of an electromagnetic field there are velocities of the analytical form $u = u_0 + u_1 \cos 2\pi t/T + u_2 \sin 2\pi t/T$ and similar expressions for v and w; where T represents a small period compared with the vibration period of the light of the visible spectrum, u_0, v_0, w_0 denote these visible velocities, u_1, v_1, w_1 are proportional to X_1, Y_1, Z and u_2, v_2, w_2 to L, M, N in Hertz's nomenclature. If, now, gravitating particles be regarded as pulsating particles, *i.e.* as particles which periodically change their volume, then it is apparent that a gravitating particle can have no constant rotation velocity, but must possess instead a periodic rotation velocity, since its moment of inertia about the axis of rotation periodically changes in consequence of the pulsation. The author then shows that a rotating particle must become a magnetic particle owing to its pulsation.

H. H. Ho.

821. *Land Magnetic Observations,* 1911–1913. **L. A. Bauer** and **J. A. Fleming.** (Carnegie Inst. of Washington, Publ. No. 175 [Dept. of Terrest. Magnetism, vol. ii., 278. pp.] 1915.)—The first portion of this

publication contains, in continuation of the previous volume of researches [see Abs. 1737 (1913)] and, in a similar manner, the results of all magnetic observations made on land by the Department of Terrestrial Magnetism from Jan. 1911 to the end of 1913. New magnetic instruments of light and portable types are described, which were designed, constructed, and used for the field operations subsequent to the work reported on in the first volume. These new instruments include two universal-magnetometer designs, viz. a combined magnetometer and dip circle, and a combined magnetometer and earth inductor [Abs. 1620 (1914)]. The results of the extensive intercomparisons of instruments at Washington, and in all parts of the world, are given in detail for each instrument.

In the second portion are given reports on some special researches; these latter have already been dealt with separately. L. H. W.

822. *Magnetic Observations during Solar Eclipse, Aug.* 21, 1914. **D. L. Hazard.** (Terrest. Magn. 21. pp. 9–14, March, 1916.)—Observations of the magnetic elements are given from the records of five stations of the United States Coast and Geodetic Survey during the day of solar eclipse, Aug. 21, 1914. C. P. B.

823. *Magnetic Survey of Egypt and the Sudan.* **H. E. Hurst.** (Survey Dept. of Egypt, Paper No. 33. Nature, 97. p. 229, May 11, 1916. Abstract.)—Results are given of field observations made by the author and C. B. Middleton between Oct. 1908 and Jan. 1914, with references also to the observations by H. G. Lyons between 1893 and 1901, and the Austrian work of Rössler in the Red Sea between 1895 and 1898 in the survey ship *Pola*. Details are given of magnetic declination, inclination, and horizontal force, all the results being reduced to the epoch Jan. 1, 1910. A notable feature is the conformity of the lines of equal dip with the parallels of latitude between 42° N. and 16° S. The magnetic equator crosses the Nile about lat. 11° N. Local disturbances were small. C. P. B.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

824. *Action of Sulphuric Acid on Alloy Steels.* **L. Aitchison.** (Chem. Soc., Trans. 109. pp. 288–298, March, 1916.)—Up to the present little or nothing has been done to correlate the corrosion of steels with their constitutions although it seems fairly obvious than any satisfactory explanation of corrosion must be based upon constitution. In order to study this question the author has adopted the method of treating various alloy steels with cold 10% sulphuric acid for a limited time and subsequently analysing the resulting solutions. It can then be observed whether the carbides are attacked or not.

Vanadium steels show the utmost regularity in their behaviour. Up to about 5·4%, the V is entirely absorbed in the carbides and none of it passes into solution in the acid. Beyond this percentage some of the element exists in the solid solution and as the vanadium content increases, increasing amounts are dissolved by the acid. As in Mo steels, the carbide appears to be immune from attack and only the solid solution is dissolved by sulphuric acid. Tungsten steel gives similar results, the saturation point being 11·5% W. Similar results were obtained with Co steels in which none of the carbon had been precipitated as graphite during the heat treatment of the samples. In Cr steels, the Cr exists in both the solid solution and the carbide, but the results show that the carbide is attacked only very slightly indeed. In Mo steels of low carbon-content there is little or no action in the carbides, and in those of higher carbon-content there is a definite attack. It now becomes reasonably certain that the majority of the carbides in alloy steels are not susceptible to the attack of dilute sulphuric acid and therefore they are not likely to be attacked by such milder corrosive agents as tap-water and brine. In all probability these alloy carbides have a much greater chemical stability than that possessed by pure carbide of iron. The consideration of the production of a rustless iron alloy is narrowed down to the consideration of the solid solution. If the action of corrosion is galvanic, then the carbides must be acting as kathodes while the solid solutions are the anodes. Since the carbides are likely to be of very similar electrical potential the action will depend very largely on the potential of the solid solutions, and the lower these can be made, the less the corrosion.

F. C. A. H. L.

825. *Research on the Corrosion Resistance of Copper Steel.* **D. M. Buck** and **J. O. Handy.** (Ind. and Eng. Chem., J. 8. p. 209, March, 1916. Am. Soc. Mech. Eng., J. 38. p. 346, April, 1916. Abstract.)—Experiments have been carried out with the object of obtaining definite information on the effects of varying percentages of copper upon the corrosion resistance of iron and steel. The results show that the addition of small quantities of copper to iron and steel greatly increases the resistance to atmospheric corrosion. The influence of copper becomes apparent when the content attains a value of 0·03 %. Its effect is almost at a maximum when the content reaches 0·05 %, although the best results on commercial steels are attained with a content of 0·25 %. The presence of sulphur in the metal, or of oxides of sulphur in the atmosphere, increases the rate of corrosion very rapidly, but these deleterious effects are entirely counteracted by the presence of copper in the steel.

F. C. A. H. L.

826. *The Transformations of Pure Iron.* (Faraday Soc., Trans. 11. pp. 125–159, April, 1916. Discussion.)—This consists of an Address by **R. Hadfield**, and the following contributed papers: "Transformations of Pure Iron," by **A. E. Oxley**; "Allotropy of Iron," by **F. C. Thompson.** Then follows a general discussion, in which Oxley's proposed new definition of allotropy is somewhat severely criticised. The original papers should be referred to by those interested in the subject. L. H. W

827. *The Corrosion of Metals, Ferrous and Non-ferrous.* (Faraday Soc., Trans. 11. pp. 183–281, April, 1916. Discussion.)—Consists of an Address by **R. Hadfield**, and the following contributed papers: "Physical and Mechanical Factors in Corrosion," by **C. H. Desch**; "Relative Corrodibilities of Iron and Steel," by **J. N. Friend**; "Influence of Composition upon the Corrosion of Steel," by **L. Aitchison**; "Note on Corrosion of Iron and Steel," by **S. Whyte**; "Zinc-Copper-Couple Hypothesis of Brass Corrosion," by **A. Philip**; "Corrosion of a Solid Solution—70/30 Brass," by **W. E. Gibbs.** Then follows the general discussion and an account of a demonstration of the Cumberland electrolytic process for prevention of corrosion. L. H. W

828. *Suggestion concerning the Statement of the Phase Rule.* **T. W. Richards.** (Am. Chem. Soc., J. 38. pp. 983–989, May, 1916.)—The most serious difficulty of the Phase Rule for beginners lies in the definition of "component." While most definitions to hand are entirely legitimate, they may lead to different choices as to the number of components in special cases. No attempt is made in the paper to give all the varying definitions or explain the limitations which must be imposed upon them, but a different method of treatment is advocated which may perhaps be more generally acceptable to chemists. Instead of stating the Phase Rule in a very simple equation, and placing all the burden of incomprehensibility upon the component, this method abandons the complex older idea of the component and substitutes another, that of the chemical individual or constitutent which is defined as follows: The individuals of any reacting system are the separate chemical substances, undecomposed in the reactions concerned, which are necessary to construct the system. The number of such individuals to be chosen is the smallest number necessary to construct the system.

On this definition the Phase Rule may be expressed without any need of reference to the number of "components" as usually defined, as: $F = (n_i + n_E) - (n_\phi - n_r)$, where F = the actual variance, or the number of degrees of freedom in the special case; n_i the number of individuals as defined above; n_E the number of physical manifestations of energy (mechanical, thermal, electrical, etc.) which are brought into play in the reaction; n_ϕ the number of phases; n_r the number of independent restrictions or fixed conditions which are determined by the circumstances of the case, but not included in the definition of the individuals. Each quantity is a small whole number, and the method of statement separates sharply the characteristics (n_i and n_E) tending to increase the variance, from those (n_ϕ and n_r) tending to diminish the variance. Ordinarily where only mechanical and thermal energy come into play, $n_E = 2$, and the equation becomes: $F = (n_i + 2) - (n_\phi + n_r)$, *i.e.* the ordinary statement of the Phase Rule with the addition of n_r, the number of restrictions, as a last term. The author opines that n_r may include only two different classes of restrictions: on the one hand, the intensity-factor of some form of energy may be restricted, or kept constant; on the other hand, one individual may (either from chemical necessity or arbitrary choice) be

kept in definite weight-ratio to some other individual, or at definite concentration in a variable phase. The paper contains a detailed discussion of these suggestions with numerous examples of familiar equilibria. A brief statement is also included of an inductive method of presenting the Phase Rule which has hitherto not been published. H. H. Ho.

829. *Density of Aqueous Solutions of Copper Sulphate and Sulphuric Acid.* **H. D. Holler** and **E. L. Peffer.** (Bureau of Standards, Bull. 13. pp. 273–281, 1916. Am. Chem. Soc., J. 38. pp. 1021–1029, May, 1916.)—The densities of copper sulphate-sulphuric acid solutions of varying concentrations have been determined at 25° and 40°. The concentrations of the solutions varied from 50 gm. to 800 gm. of total solute per kg. of solution. Within the range studied the density of the solutions is approximately a linear function of the concentration. The densities of solutions of equal-weight (not equivalent) concentrations of copper sulphate ($CuSO_4 5H_2O$) and of sulphuric acid are nearly identical. As a result of this, the densities of solutions containing appreciable amounts of each component are dependent principally upon the total concentration of the two solutes, and are almost independent of their proportion. For example, a solution containing 50 gm. of copper sulphate and 150 gm. of sulphuric acid per kg. has practically the same density (1·1355) as has a solution containing 100 gm. of copper sulphate and 100 gm. of sulphuric acid (1·1350). T. S. P.

830. *Microscopic Structure of Semi-permeable Membranes and the part played by Surface Forces in Osmosis.* **F. Tinker.** (Roy. Soc., Proc. 92. pp. 357–372, May 6, 1916.)—With the view of obtaining some further insight into the mechanism of osmosis, the author has made a careful microscopic examination of precipitation films of copper ferrocyanide, copper silicate, Prussian blue, ferric silicate, and compared them with a precipitate of barium sulphate. The common precipitation semi-permeable membranes were found to be composed of small precipitate particles, the size of which ranged from 0·1 to 1·0 μ. The particles were closely packed together. Each of these precipitate particles is, however, not simple in structure, but is an aggregate formed by the flocculation of sub-microscopic colloidal particles. The particles composing the membrane are smallest in the case of copper ferrocyanide and Prussian blue. The precipitation membranes resemble the colloid gels both in their method of formation and in the changes which they undergo in various solutions. Like ordinary gels they are possessed of great tensile strength, which varies in membranes of different kinds. Their stability in the colloidal condition also varies greatly. Although showing the physical properties of gels, they have not the same mechanical structure, the membrane being much more closely knit together than the gel proper The pores in a copper ferrocyanide membrane range from 8 to 60 $\mu\mu$ in diam., the average diam. being 15 to 20 $\mu\mu$. The pore size is too great for the membrane to act osmotically by exerting a selective mechanical blocking action. On examining the different membranes, it was found that the order of pore size is the same as that of the efficiency of the membranes as semi-permeable membranes. Copper ferrocyanide and Prussian blue are the most efficient as semi-permeable membranes, and they are also the membranes with the smallest pores. There is a very close connection between the osmotic properties of a membrane and the extent to which the membrane capillaries are under the control of surface forces. Osmotic effects are probably the result of selective adsorption phenomena occurring at the surface of the

membrane and in the capillaries, the membrane being relatively impermeable to solutes which are negatively adsorbed, but permeable to solutes which are positively adsorbed. A. F.

831. *Osmose of some Solutions of Electrolytes with Porcelain Membranes, and the Relation of Osmose to Membrane Potential.* **F. E. Bartell** and **C. D. Hocker.** (Am. Chem. Soc., J. 38. pp. 1036–1050, May, 1916.)—Osmotic cells were constructed using porcelain membranes of different degrees of porosity and such that the diameters of the largest pores were about $0{\cdot}2\,\mu$. With these cells the osmosis of solutions of various electrolytes was tested. The electrolytes used included: (*a*) nitrates of K, NH_4, Na, Li, Ba, Zn, Mn, Mg, Al, and Th, the concentrations varying from 0·0005 *m* to *m*; (*b*) 0·1-*m* solutions of KNO_3,KCl, KBr, KI, KCNS, CH_3. COOK, K_2SO_4, K_2CrO_4, K_3PO_4, $K_4FeC_6N_6$, $K_3FeC_6N_6$; (*c*) solutions of HCl and NaOH varying in concentration from 0·001 *m* to 0·2 *m*; (*d*) 0·1-*m* solutions of K, Li, and Ba nitrates when the membranes were immersed in hydrochloric acid or sodium hydroxide solutions varying in concentration from 0·0001 *m* to 0·01 *m*. The osmosis of these electrolytes was found to vary in different ways with the concentration, some electrolytes giving positive effects which increased continuously with the concentration of the electrolyte, whilst others give positive effects at low concentrations and negative effects at higher concentrations, the positive osmosis decreasing continuously with increase in concentration of the electrolyte. For some electrolytes there is a concentration which gives the maximum (minimum) positive osmosis, higher or lower concentrations giving smaller (greater) positive effects. At a certain concentration, somewhat different for each salt, all the nitrates investigated, except those of Al and Th, give an effect which is practically zero. This concentration for KNO_3 and NH_4NO_3 is about *m*; for $NaNO_3$, 0·1 *m*; for $LiNO_3$, 0·05 *m*; for $Ba(NO_3)_2$, 0·02 *m*; and for Zn, Mn, and Mg nitrates the concentrations lie between 0·02 and 0·01 *m*. The osmosis seems to be closely related to the electrical orientation of the membrane, and to the magnitude of the p.d. existing between the solutions bathing, the two faces of the membrane. In most cases the orientation of the membrane is that which would be expected from the difference in migration velocities of the ions without considering the membrane, but in a few cases the orientation is the reverse. In all cases of the binary salts of univalent ions, the greater the rate of diffusion of salt through the membrane of the cells the greater the positive osmosis. This rate of diffusion is always closely related to the magnitude of the cell potential.

The experimental facts are explicable in the light of the theory given in the next Abstract. [See Abs. 1929 (1914).] T. S. P.

832. *Relation of Osmose of Solutions of Electrolytes to Membrane Potentials. Theoretical.* **F. E. Bartell** and **C. D. Hocker.** (Am. Chem. Soc., J. 38. pp. 1029–1036, May, 1916.)—In the light of the following assumptions, the results given in the preceding Abstract can be explained. (1) Abnormal osmosis—that is, from the concentrated to the dilute solution—is due primarily to an electrical effect, and is analogous to electric osmosis. (2) This osmosis is caused by the passage of a charged liquid layer along the capillary tubes of the membrane, the passage of this layer being brought about by the driving force of a p.d. which acts as though it were set up between the two faces of the membrane. (3) The charge on the membrane—and hence the charge on the liquid layer—may be modified or the sign may

be reversed by selective adsorption of the ions of electrolytes; and other ions than $H^{\cdot}$ and OH' may materially affect the charge on the membrane. (4) The p.d., which seems to act between the two faces of the membrane, is primarily due to contact electrification, the magnitude of which is dependent upon a difference of migration velocities of the ions in the membrane. This p.d. may, however, be altered by other factors, such as adsorption. (5) Osmosis is related to diffusion, since the diffusion of the ions seems to determine to a large extent the polarisation of the membrane. (6) The extent of osmosis may be affected by the relative volumes of water and salt solution on the two faces of the membrane, inasmuch as this factor may affect the diffusion of the salt through the membrane.

The membrane, when immersed in water or any electrolyte in which there is little tendency for preferential adsorption of ions, bears a negative charge and the adjacent water layer a corresponding positive charge. Kathions are much more adsorbed than anions, the negative ions, with the possible exception of OH' and a few polyvalent anions, having little effect on the charge of the membrane. The alterations of the charge on the walls of the capillary tubes of the membrane by an adsorbed ion will be greater the higher the concentration of the electrolyte. The potential between the two faces of the membrane will be in the direction required by Nernst's theory, and will be greater the greater the concentration of the electrolyte, unless some effect such as adsorption interferes. If the movable water layer and the solution end of the membrane are charged with electricity of opposite sign the osmosis will be positive; if charged with the same sign the osmosis will tend to be negative. T. S. P.

833. *Density and Viscosity of Aqueous Solutions with Special Reference to Nitric Acid.* II. *Viscosities.* **W. R. Bousfield.** (Chem. Soc., Trans. 107. pp. 1781–1797, Dec., 1915.)—A new type of viscometer of the gravity-flow type is described, which is entirely enclosed and operated by air-pressure or suction. Special devices are used to prevent dust from getting into the apparatus and from clogging the capillary. Eight years' experience has shown that an accuracy of 1 part in 1000 is readily obtainable in measurements made with this instrument. The measurements now made with aqueous solutions of nitric acid show that at 4° C., on addition of acid to water, the viscosity diminishes continuously, whilst at 25° it increases continuously: at 11° it increases very slightly to a shallow maximum, then reverts to its original value, diminishes to a minimum, and finally increases rapidly as at 25°. This remarkable behaviour must be attributed to the abnormal constitution of water and to the changes of constitution produced by changes of temperature and by the presence of the solute. When concentrated solutions are examined, a sharp maximum is observed at 68·6 % HNO_3, corresponding with the definite hydrate $HNO_3, 2H_2O$, followed by a diminution of density to the value for the anhydrous acid. This may obviously be attributed to the formation of a definite compound. It may be noted that at 11° and 18° C. the complete curves from 0 to 100 % show two maxima and one minimum. T. M. L.

834. *Osmotic Pressure or Osmotic Suction—which?* **F. Tinker.** (Nature, 97. pp. 122–123, April 6, 1916.)—The tendency of a liquid to diffuse is measured by its diffusion pressure, which may be defined as the bombardment pressure exerted by the liquid molecules on either side of a plane of unit area placed anywhere within the liquid. By the introduction of

a solute, the absolute concentration of a solvent is reduced, and the diffusion pressure is reduced in the same way. The diffusion pressure of a solvent in a solution is therefore always less than that in the pure solvent itself, and the osmotic pressure becomes proportional to the difference between the absolute concentrations of the *solvent* on the two sides of the membrane, and therefore also approximately proportional to the concentration of the solute, because the latter is itself approximately equal to the difference in solvent concentration on the two sides. The phenomenon of osmotic flow is therefore due to the residue or excess of *solvent* molecules on the pure-solvent side. By withdrawal from the solution of all the solvent molecules, and an equal number from the pure solvent, the *difference* in solvent concentration on the two sides of the membrane is maintained, and as the concentration of molecules is now small, they may be regarded as following the gas laws. On this basis we find the osmotic pressure equal to the gas pressure. The fundamental difference between osmotic phenomena in the gaseous and solution states is that whereas the active molecules have a vacuum for a medium in the gaseous case, they have a liquid solvent for a medium in the solution case. The other differences between compressed gases and concentrated solutions nearly all proceed from this fundamental one. A. F.

835. *Vapour-pressures of Saturated Aqueous Solutions.* **M. P. Applebey** and **W. Hughes.** (Chem. Soc., Trans. 107. pp. 1798–1814, Dec., 1915.)—Berkeley and his collaborators have called attention to the anomalous properties of saturated aqueous solutions of thallium nitrate, in that whilst the osmotic pressures of most strong solutions are far greater than the calculated values this salt gives values which are actually smaller. This was determined by a dynamic measurement of boiling-point: the present research was carried out by a static method, and included comparative measurements of the vapour pressures of saturated solutions of sodium nitrate (120° to 123°), sodium sulphate (101° to 104°), and thallium nitrate (94° to 109°). The results for the two latter salts were in excellent agreement with those obtained by Berkeley; the exceptional behaviour of thallium nitrate, which was fully confirmed, was proved not to be due to any volatility of the salt. The ratio of osmotic pressure to concentration, instead of increasing steadily with the concentration as in the other two cases, reaches a maximum at 8 gm.-mols. per litre and then diminishes. It is suggested that this is due to association or polymerisation of the salt as water is withdrawn, and that this process may continue until the pure fused salt is left in a highly polymerised or associated condition. T. M. L.

836. *Method of Exhibiting Velocity of Iodine Ions in Solution.* **S. W. J. Smith.** (Phys. Soc., Proc. 28. pp. 157–161, April, 1916.)—Dilute solutions of potassium iodide and potassium chloride of equimolecular concentration have almost the same electric conductivity. They are, therefore, of interest in connection with the direct measurement of ionic velocities. The author describes a simple method of observing their common boundary. For this purpose a little mercuric chloride is added to the potassium chloride solution. An extremely thin layer of mercuric iodide then forms where the two solutions meet. The method is particularly convenient for lecture purposes, and an approximate value of the ionic velocity can be obtained in a few minutes.

Examples are given of the use of the method. The current is first passed in the direction which causes the iodine ions to travel towards the chloride,

The chlorine liberated at the anode in this case supplies a means of re-determining the velocity of the ions when, the current being reversed, they move in the opposite direction. AUTHOR.

837. *Dissociation of Hydrogen into Atoms.* III. *Mechanism of the Reaction.* **I. Langmuir.** (Am. Chem. Soc., J. 38. pp. 1145–1156, June, 1916.)—The velocity of the reaction by which hydrogen is dissociated in contact with a heated tungsten wire [see Abs. 1932 (1914), 787 (1915)] is so enormous as to prove definitely that the reaction cannot depend on diffusion of hydrogen into the metal even to the depth of a single atom. A general theory of heterogeneous chemical reactions is now outlined in which the reaction is assumed to take place in the actual surface layer of atoms. Development of this theory in the case of hydrogen leads to equations which become identical with that previously derived by other methods if the assumption is made that the hydrogen evaporates so rapidly from the surface that only a negligible fraction of the surface is covered at any time; it has already been shown that this equation is in complete agreement with the experimental results (*loc. cit.*). The conclusion that very little of the surface is covered is in good accord with the fact that the accommodation coefficient of hydrogen is 0·19 at temperatures below 1500° K., whereas the "chemical" accommodation coefficient a_1 for the dissociation of hydrogen is 0·68 at high temperatures. The fact that the emission of electrons from heated tungsten is not affected by the presence of pure hydrogen is additional evidence that the fraction of the surface covered by atoms or molecules of hydrogen must be very small. T. H. P.

838. *Explanation of the Migration of the Ions.* **S. W. J. Smith.** (Phys. Soc., Proc. 28. pp. 148–155; Disc., 155–156, April, 1916. Electrician, 77. pp. 498–499, July 14, 1916.)—The author's object is to show how a familiar diagram, appearing in many text-books, can be improved in a way which makes it easier to appreciate what happens at the electrodes in the simpler examples of Hittorf's method of determining the migration constant. AUTHOR.

839. *New Method of Determining Ionic Velocities.* **[Mrs.] C. H. Griffiths.** (Phys. Soc., Proc. 28. pp. 132–146; Disc., 146–147, April, 1916. Electrician, 77. pp. 82–83, April 21, 1916. Abstract.)—In the experiments described the kathode, which consists of a horizontal copper disc perforated with two holes, is mounted in a cylindrical glass tube open at the lower end. The whole is suspended from the beam of a balance, and is immersed in a vessel of copper sulphate. The anode is a copper spiral fixed in the electrolyte some distance below the mouth of the kathode vessel. From the rate of change of weight of the suspended system during the passage of a current the ionic velocities can be determined. AUTHOR.

840. *An Electrochemical Action on Glass.* **F. F. S. Bryson.** (Engineering, 101. pp. 517–518, June 2, 1916.)—The author sealed the Pt-wire (anode) of a Wehnelt interrupter through the end of a glass tube containing mercury. The seal was made by the Burnside process [see Abs. 914B (1913)], various kinds of glass serving as flux. A crater was always seen to form round the wire, but the corrosion was less marked with Jena glass than with British and other German glasses. The glass was not rendered brittle, nor did it crack, though it was partly devitrified by the sealing-in process—for subsequent annealing did not make any difference. The corrosion was due to pitting, and was partly electrolytic but not entirely so; for the pitting was also

observed when the electrode was the kathode. The high local temperature, reduction and oxidation of the metal and glass by the hydrogen and oxygen liberated by the dissociation of the water-vapour, and the ultra-violet radiation contribute to the corrosion, it is suggested. H. B.

841. *Overvoltage.* **C. W. Bennett** and **J. G. Thompson.** (J. Phys. Chem. 20. pp. 296–322, April, 1916.)—The authors give a general discussion of the question of overvoltage, and the various theories put forward in connection with the same. They come to the conclusion that any chemical reaction which consists of more than one step cannot be strictly reversible when electricity is generated, but requires more electrical energy to re-form the substances than is given by the reverse reaction. The irreversibility gives rise to overvoltage, since the quantity factor is constant. Overvoltage is therefore defined as the excess energy required to form a substance over that given by the resolution of the product formed to the original state. It is the amount of energy by which one measures the irreversibility of the process or change. This definition applies not only to overvoltages where gas is deposited, but also to cases where a metal is deposited at the kathode. From this definition a general and elaborate theory of overvoltage is developed, the theory depending on the assumption that the excess of the back e.m.f. of the system during electrolysis over the reversible e.m.f. of the system consisting of the final products is due to the accumulation during such electrolysis, of unstable intermediate products above the equilibrium concentration. These intermediate products are undoubtedly active hydrogen, H, active oxygen, O, for example, in the case of gases, and atomic metal, analogous to vaporised metal in the case of metal overvoltage. Various experiments are quoted which show that these intermediate products are more reactive than the final products, and are sufficiently active to explain the overvoltages found experimentally. Thus active hydrogen, made by exposing the gas to ultra-violet light or by heating a filament of Mo-wire in it almost to the volatilisation-point, is capable of reducing cadmium sulphate solutions to cadmium and zinc oxide to zinc. It is also shown that the theory satisfactorily explains the known facts of overvoltage, for example, the effects of temperature, current density, etc., but the details are too extensive to be given in an abstract. T. S. P.

842. *Depolarisation by Electric Waves.* **W. D. Bancroft.** (J. Phys. Chem. 20. pp. 402–406, May, 1916.)—A theoretical paper in which it is shown that electric waves must cause depolarisation if it is assumed that electrical stress cuts down the adsorption of a gas by a solid. This assumption is a necessary consequence of Schuster's work on disruptive discharges, and has been shown to account for the behaviour of fountains, impinging jets, rolling drops, and soap-bubbles when electrified slightly [see Abs. 491 (1916)]. It is shown, from the work of others, that electric waves do decrease overvoltage at the kathode and at the anode, and that the assumption accounts for all the facts so far known. It is also pointed out that measurements of decomposition voltage involving the use of an intermittent direct current are subject to an error which is perhaps not negligible. T. S. P.

843. *Overvoltage and Monatomic Hydrogen.* **W. D. Bancroft.** (J. Phys. Chem. 20. pp. 396–401, May, 1916.)—A theoretical paper, in which the author shows that the theory of the irreversible electrolytic decomposition of water gives a very plausible explanation of some of the peculiarities of sodium amalgam, chromous chloride, and zinc dust. The irreversible decomposition of water is considered to be due to the formation at the kathode of an inter-

mediate product which is a stronger reducing agent than hydrogen, and which gives rise to hydrogen relatively slowly, whilst at the anode a stronger oxidising agent than oxygen is formed, which gives rise to oxygen relatively slowly [compare Bennett, Abs. 841 (1916)]. The intermediate product formed at the kathode is assumed to be monatomic hydrogen, and high over-voltage, with corresponding high reducing power, is due to monatomic hydrogen being present in excess of the concentration required by the equilibrium $2H \rightleftarrows H_2$. The normal relation existing between high over-voltage and high reducing power may, however, be obscured, or be made to disappear entirely: (1) by a special adsorption of the reacting substance by the electrode, (2) by a specific catalytic action of the electrode on the reaction, or (3) by catalysis of the reaction by the solute. Whilst nascent hydrogen may be considered to consist in part of electrically neutral monatomic hydrogen, it must be recognised that the percentage of monatomic hydrogen may vary enormously, and that nascent hydrogen from one source is not necessarily equivalent to nascent hydrogen from another source.

T. S. P.

844. *Passive State of Iron in Nitric Acid.* **J. G. Brown.** (Science, 43. p. 758, May 26, 1916. Paper read before the Pacific Phys. Soc.)—The e.m.f. of the cell: Fe | solution of HNO_3 | concentrated HNO_3 | Pt, has been measured at room temperature from the instant it was made until it reached a steady state, using eight solutions of nitric acid of densities varying from 1·01 to 1·41; the iron electrode was either at rest or in motion. Observations were made with a low-power microscope of the changes which took place on and around the iron. The results show that the ferrous oxide which forms on the iron at the start in all acid densities does not affect the e.m.f. of the cell, but the liquid products do. If the iron is kept at rest in acid up to a density of 1·17 the e.m.f. is increased by the presence of ferrous nitrate, whilst in acids of greater density the e.m.f. is lowered by some other product which forms a bright red liquid film over the oxidised surface of the iron. The red colour may be due to the formation of an unstable compound between nitric oxide and ferrous nitrate, which compound determines the semi-passive state. In acids of density greater than 1·25 there is an explosive reaction between the ferrous oxide and the red liquid, after which the iron is in the passive state. There is no indication of the existence of any kind of film after the passive state is reached. It seems probable that both the ferrous and ferric reactions take place in acids of all densities, but in those of greater density than 1·25 the ferrous reaction may be quenched by the sudden reaction between the ferrous oxide and the red liquid, while the ferric oxide remains. If this explanation is correct, it follows that iron is active whenever the conditions are such that ferrous ions are formed, but it is passive whenever these ions are not formed. T. S. P.

845. *Change of Potential of the same Metal in Different Electrolytic Solutions.* **P. F. Hammond.** (Science, 43. pp. 757–758, May 26, 1916. Paper read before the Pacific Phys. Soc.)—The cells measured were made up as follows: Pt | $\frac{n}{10}$ $AgNO_3$ or $\frac{n}{10}$ KNO_3 | $\frac{n}{10}$ solution of nitrate of another metal | Pt. The nitrates used were those of Ag, Fe(ic), Cu, H, Pb, Ni, Co, Fe(ous), Cd, Zn, Mg, Ca, Ba, Na, and K. The single electrode potentials against the electrode Ag | $\frac{n}{10}$ $AgNO_3$ as zero, are in the order given, the potentials increasing up to 3·94 volts for potassium nitrate. T. S. P.

846. *Electrolysis of Nitric, Sulphuric, and Orthophosphoric Acids, using a Gold Anode.* **F. H. Jeffery.** (Faraday Soc., Trans. 11. pp. 172–180, April, 1916. Chem. News, 112. pp. 227–231, Nov. 5, 1915.)—The apparatus used was formed of a Jena beaker of 800 cm.^{3} capacity, inside which was a porous pot; the volume of the anolyte was about 550 cm.^{3} The anode was of gold, whilst the kathode was of Pt and was placed inside the porous pot. The anolyte and katholyte consisted of the same acid in each experiment, and in various experiments the strength of the solutions was varied. With nitric acid it was possible to obtain a solution (anolyte) from which auri-nitric acid, $HAu(NO_3)_4$, $3H_2O$, could be isolated. The evidence indicated that the gold anode dissolved partly in the tervalent state and partly in the univalent state, but no complex aurous compound could be isolated. Deposits of gold oxide, generally consisting of mixtures of the aurous and auric compounds, were also obtained, and a method is given for making hydrated auric oxide. With solutions of sulphuric acid or orthophosphoric acid as electrolyte, evidence was obtained that the gold anode goes into solution as a complex anion, but no complex salt could be isolated. Deposits consisting of various mixtures of aurous and auric oxide were obtained, as in the case of the nitric acid electrolyte. T. S. P.

847. *Electrolysis of Concentrated Hydrochloric Acids, using a Copper Anode.* **F. H. Jeffery.** (Faraday Soc., Trans. 11. pp. 181–182, April, 1916.)—The apparatus used was similar to that employed with gold anodes [see preceding Abstract]. The electrolyses were performed in an atmosphere of nitrogen when concentrated hydrochloric acid was the electrolyte, and in an atmosphere of CO_2 when the anolyte consisted of a solution of potassium chloride. With such electrolytes it was found that a copper anode goes into solution as complex anions, which correspond with the complex acid H_2CuCl_3. From the potassium chloride electrolyte crystals were isolated having a composition agreeing with the formula K_2CuCl_3. T. S. P.

848. *Transference of Electricity by Colloidal Particles.* **F. Powis.** (Faraday Soc., Trans. 11. pp. 160–164, April, 1916.)—The formula $e = 6\pi nru \mid H$ has been used to calculate the mean charge (e) carried by the particles in a colloidal solution (Ellis, Zeitsch. physikal. Chem. 78. p. 321, 1911). The author points out that if we know the number of particles present in unit volume and their velocity under unit potential gradient we can calculate what amount they would contribute to the conductivity of the solution if they carried a charge equal to n times that on a univalent ion. Conversely, if we knew what part of the conductivity was due to transference of electricity by colloidal particles we could calculate the mean charge carried by them. Using the experiments of Burton [see Abs. 968 (1906)] as a basis, the value of n is calculated to be between 2×10^6 and 3×10^7. These values are much higher than that ($n = 795$) calculated from Stokes' formula as given above. In order to explain the discrepancies the author puts forward a theory according to which a colloidal particle absorbs anions and kathions, not so that they form two distinct layers round it, as seems to be generally supposed, but in such a way that the concentration of each gradually decreases with increasing distance from the particle until it finally becomes equal to that in the bulk of the surrounding medium. By means of this theory the movement of particles under the influence of an electric field can be explained, as also the predominating influence which ions of higher valency usually exert. Other phenomena are also capable of explanation. T. S. P.

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